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PROGRESS REPORT

Program

On



Application Of Communications Satellites

To

Educational Development

November, 1971.

PROGRESS REPORT

PROGRAM

ON

APPLICATION OF COMMUNICATIONS SATELLITES

TO

EDUCATIONAL DEVELOPMENT

SUBMITTED TO

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This report was prepared by R. P. Morgan, Program Coordinator and J. P. Singh, Research Engineer. It includes many extensive written contributions by program personnel. Mrs. Emily Pearce performed the very skillful typing of the manuscript.

SUMMARY

Washington University (St. Louis) has been undertaking an interdisciplinary program supported by NASA which has as a major objective the definition of educational services which communications satellites may help provide and the synthesis of systems for delivering these services in the United States. In order to ensure that the study takes into account all systems aspects--political, social, organizational, administrative as well as economic and technical--the work has been undertaken by an interdisciplinary group of research personnel representing a broad range of disciplines and skills. The program relates directly to the purposes of NASA by focusing upon the potential development and application of space technology to help meet the needs of society in the field of education.

During the period from November, 1970 to November, 1971, substantial progress has been made in three primary program categories: 1) needs analysis, 2) communications technology studies, and 3) systems synthesis.

Needs Analysis

We have chosen to base our design of satellite systems for education upon careful studies of existing and planned educational telecommunications services, their nature, current status and future utilization. These studies lead to identification of future opportunities for satellite telecommunications in education. Reviews and assessments of the following areas have been completed: (a) communications media and educational technology with emphasis on still-picture television, microimaging devices and video tape recorders, (b) telecommunications and computer-based instruction, (c) other educational computer services and computer communications, (d) instructional television utilization, and (e) electronic educational dissemination services, including public television, cable TV, ITFS, closed-circuit TV. Another study underway, which has already yielded useful results, is being performed on library utilization of telecommunications. Backing up these investigations are related work, essentially completed, on estimates of available budgets for media-technology in 1975-1985, assessment of the impact of educational technology and the

utility of educational production functions, and legal issues related to use of educational technology.

Based upon the work outlined above, we have attempted a first cut at estimates of ranges of utilization of various educational telecommunications services for 1975 and 1985; instructional and public television, computer-aided instruction, computing resources and information resource sharing for various educational levels and purposes. Also estimated are percentages of this utilization which might potentially be delivered using communications satellites. Our studies indicate that communication satellites may have an important role in 1) interconnecting educational institutions, particularly those related to higher education and research, for the purpose of sharing instructional, research, and administrative resources 2) interconnecting remote and isolated schools with service centers to provide students and teachers with equitable access to services such as raw computing power, computer-assisted instruction, etc. which currently are more readily available in urban and suburban areas, and 3) delivery of public and instructional television program material for in-school as well as for in-home utilization.

Communications Technology Studies

Studies completed include work on transmission schemes for still-picture television and work on the use of Gunn effect devices as amplifiers and as switching elements. A major effort has been initiated on the design and development of TV receiver front ends for direct satellite reception at 12 GHz. Emphasis is now being directed towards a multi-channel receiver that can be used at the headend of a cable television system. A detailed analysis of operating frequencies for educational satellite communications has been completed. Continuing studies are also being carried out of modulation, multiple access, orbit and spectrum utilization and other techniques of importance in satellite system design and synthesis.

Systems Synthesis

Based upon the results of WARC, further work has been carried out in examining the alternatives that were developed in the last Progress Report and narrowing the choice to a selected few potential systems. The public service offerings of the domestic satellite applicants have been examined, especially with regard to public television distribution and small earth-terminal operation and have been found to be lacking in many respects. Preliminary systems work for a variety of educational computer communications which would appear to be of considerable importance indicates that high powered satellites linked with small earth-terminals look more attractive for educational users than operational satellites currently available or proposed.

Two major studies have been completed which contribute to the systems synthesis phase of the project. A study of organizational and administrative aspects of a large-scale instructional satellite system to be used with schools outlines requirements for a system with demand and scheduled access capability. In the near future, we plan to evaluate its technical feasibility, design and economics. An analysis of future development of instructional television has been completed, with emphasis on the use of video tape recorders and cable television. This study provides essential information on the costs and capabilities of ground distribution facilities for educational television services, which clearly are of importance in connection with educational satellite systems.

We have acquired a communications satellite system synthesis program developed for NASA by General Dynamics/Convair, and after a considerable amount of effort it is now operational on the Washington University IBM 360-50 computer. Initial runs are being made for a small number of cases. We are planning to incorporate certain modifications in the program with respect to launch vehicle options and to use this program extensively in the future as an aid in educational satellite systems synthesis. We have also developed an in-house computer program that maps satellite antenna foot-prints on earth.

During the period in question, we have initiated a study of the potential uses of a communications satellite in Appalachia in cooperation with the Appalachian Regional Commission. A major Conference on Satellites for Education was held at Washington University, representing an important forum for discussion of this topic involving a broad spectrum of concerned parties. The overall program continues to be closely related to the academic goals and objectives of Washington University. A new master's degree has been created in Technology and Human Affairs which permits more direct involvement of students in problem-oriented thesis studies such as those in the satellite-education program. The latter has been a strong factor in the creation of the new master's degree.

The report concludes with an outline of future work to be undertaken and an evaluation of progress during the past year. The period of this Progress Report has seen a substantial increase in research output. We anticipate that a fourth year of support will enable us to achieve with some degree of satisfaction the primary goals and objectives of our program in the needs analysis and systems synthesis areas and serve as a transition to more direct involvement with user groups in both policy-planning studies and actual educational experiments involving communications technology. Specific research tasks are in the process of being defined which plug gaps which have become apparent during the previous year and which capitalize upon the interests and expertise of interdisciplinary faculty and staff members. In the area of communications technology studies, work has been initiated towards design and exploratory R and D of a multichannel 12 GHz receiver for use with cable television headends. This work, which gives significant promise of providing a major advance in the development of satellite systems technology, is now at the stage where a significant new funding input is required.

I. INTRODUCTION

I. INTRODUCTION

Since September, 1969, Washington University (St. Louis) has been carrying out an interdisciplinary research and education program which examines the application of communications satellites for helping to meet educational needs, primarily in the United States. A major objective of this NASA-supported program is to define the educational services which communications technology and, in particular, communications satellites may provide and then to synthesize hypothetical systems for delivering these services. In order to ensure that the study takes into account all systems aspects--political, social, organizational, administrative as well as economic and technical--the work has been undertaken by an interdisciplinary group of research personnel representing a broad range of disciplines and skills. Table 1 lists program personnel.

In previous progress reports,^[1,2] program objectives, organization and management have been described in detail. In this report, we will concentrate on summarizing the results of research obtained during the 12-month period since the last progress report dated November 12, 1970. The results have been divided into three main categories, a) Needs Analysis, b) Communications Technology Studies and c) Systems Synthesis (See Figure 1). Related educational and professional activities are then described. The report concludes with a discussion of future work.

TABLE 1
PROGRAM PERSONNEL

Barry D. Anderson, Assistant Professor of Education

Harold J. Barnett, Professor of Economics

Neil N. Bernstein, Professor of Law

Arthur Denzau, Research Assistant in Economics

Banarsi Dhawan, Research Assistant in Economics

James R. DuMolin, Communications Analyst, Center for Development
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Edward Greenberg, Professor of Economics

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Harris Jackoway, Research Assistant in Education

Roger McClung, Research Assistant in Economics

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Robert P. Morgan, Associate Professor of Engineering and
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Burton Newman, Research Assistant in Electrical Engineering

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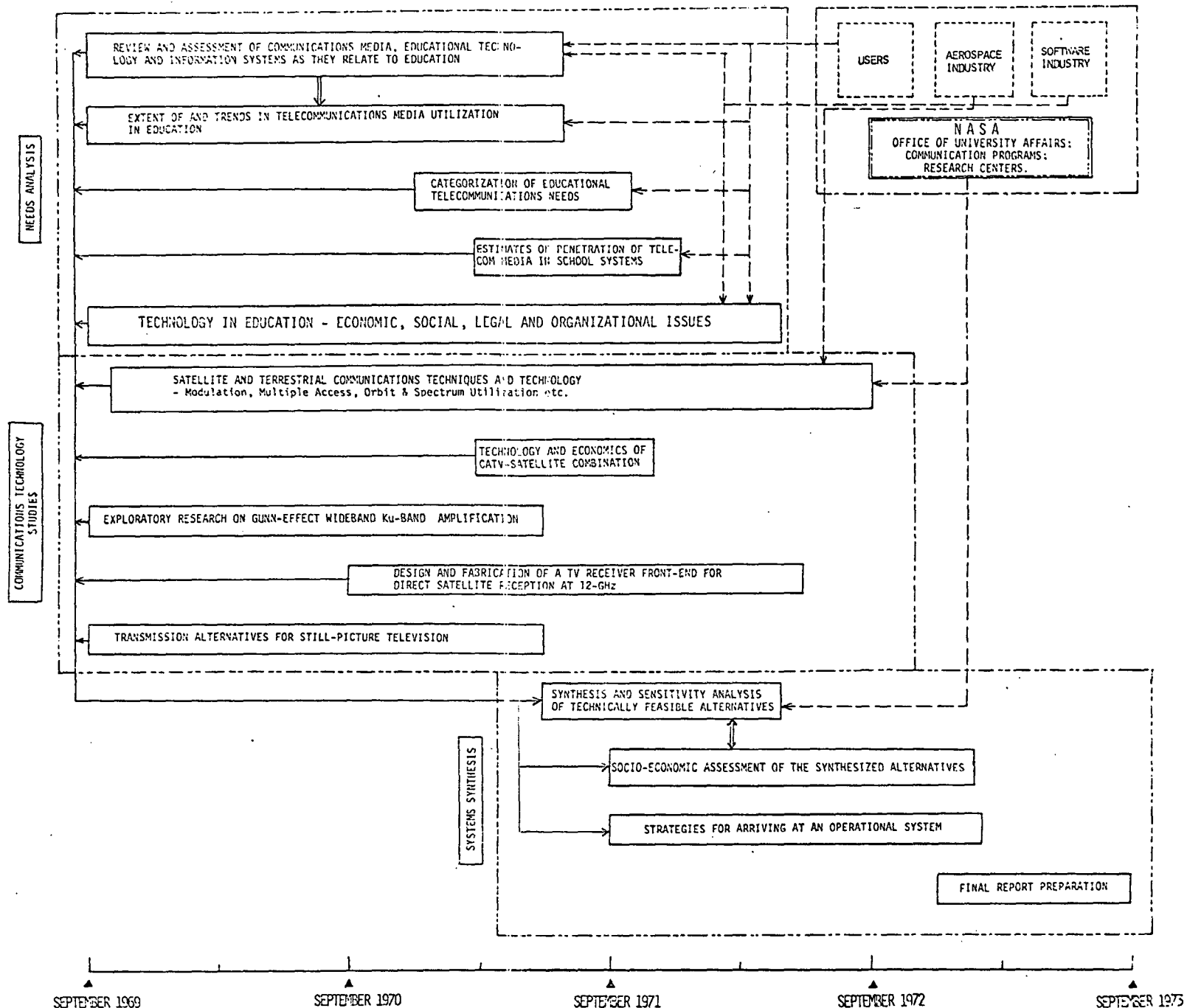


Figure 1. Study Plan of Washington University Program on Application of Communications Satellites to Educational Development

Prepared
November 1970

II. NEEDS ANALYSIS

DEFINITION OF EDUCATIONAL TELECOMMUNICATIONS SERVICES

II. NEEDS ANALYSIS; DEFINITION OF EDUCATIONAL TELECOMMUNICATIONS SERVICES

II.A. INTRODUCTION

During the past year, a substantial portion of our efforts have been directed towards examining the status of educational telecommunications media and services which might become part of future educational satellite systems. Our approach has been to carry out detailed studies of the status of existing services and estimates of future trends and then, with this as a background, to make estimates of future services which might be provided by long-distance telecommunications in general and communications satellites in particular.

In our Progress Report of one year ago, we were much less farther along in this process. We did attempt to provide requirements, but our estimates were, at best, guesses based upon no detailed background studies. Furthermore, we considered only television. Now, we have expanded our field of vision to include a variety of other services, including computer-aided instruction, computer resources and information resource sharing. Our guesses now are more "educated" than they were previously.

A word is in order about the phrase "Needs Analysis". At various times, we have used the terms "educational needs" and "requirements" in referring to the quantitative description of the kinds of information rates and capacities which an educational satellite system might be called upon to handle. It has been suggested to us that we might better use the term "opportunities" to reflect the fact that new technology essentially provides opportunities which the mission or system designer seeks to define more precisely as requirements. Suffice it to say that we are proceeding on the premise that one of our primary tasks is to define missions for educational communications satellites. We have therefore adopted a prescriptive approach in which, based upon current status and trends, we will attempt to define requirements which seem realistic but which do take advantage of the opportunities which the technology provides.

There are clearly pitfalls in proceeding in this way. If one specifies large-scale requirements for instructional television or computer-based instruction, it must be kept in mind that current utilization of these technologies is minimal at best. To bring large-scale utilization

into being may require certain structural changes in education which may or may not come about. Furthermore, large-scale utilization is bound to have certain socio-economic consequences. Thus, we enter the realms of both technological forecasting and technology assessment. Our concern is with optimizing the use of one particular innovation, i.e. a communications satellite and measuring its costs and benefits to society in the field of education.

We recognize that some of the studies performed in the project have turned up important issues badly in need of future study. We refer to the dearth of information on educational production functions, the lack of evaluation of the costs and benefits of instructional television and the lack of research of the mix of teachers and technology required to provide optimal learning. However, we proceed as best we can with what limited information is available.

For the purposes of analysis, educational/instructional telecommunications services can be grouped under the following three broad service categories:

(1) Information Dissemination and Broadcast Services

This type of service can be characterized by those systems which provide transfer of information between many terminals and one centralized terminal. Messages are originated by human beings in voice, graphic and pictorial form for immediate consumption of human beings. It is essentially a one-way transfer of information on a point-to-multipoint basis as found in conventional radio and television broadcasting, Instructional Television Fixed Service without interaction, etc.

(2) Interactive Telecommunications Services

This could be further broken into two categories: (1) systems which involve interaction between two or among several human beings, and (2) systems which involve interaction among man and machine. Both categories require two-way transmission circuits.

Systems and/or services such as teleconferencing via picture-phone and telephone, talk-back television teaching systems, etc. come under the first category. The second category of services is typified by the systems/services in which a large number of terminals are capable of making an inquiry to a single repository of information which is capable of retrieving the requested information and responding to the inquiry. The

central system can also have the capability, depending upon the system requirements, to digest the data, making computations on these data and provide the answer. One thing that should be remembered here is that the interaction takes place at human speeds at a relatively slower rate than the incoming data. Examples of such services are remotely located (from the main processor) Computer Assisted Instruction/Computer Managed Instruction (CAI/CMI) terminals, remote medical diagnosis, information search, remotely located on-line, time-shared terminals for computer-aided problem solving and scientific information processing, etc. This type of service would in most cases require two-way point-to-point communication. Channel capacity requirements, in general, would be asymmetrical. In one direction, data entry from a key-board or light pen, would be in the range of 12-150 bits/second, whereas in the other direction (from the central terminal or processor to the terminals interfaced with the many inquirers) data rate requirements could be anywhere between 75-9600 bits/second depending upon the type of interface that is employed--teletype, high speed Cathode Ray Tube (CRT), serial impact printer or non-impact printing devices.

(3) Computer Interconnection Services

This category of services includes time-sharing in the strictest sense of the term, that is, it has the characteristic of sharing a computer's time among a group of users and is closely allied to the inquiry and response described in the interactive services except for the fact that transmission rates are much higher and interaction is not limited by the human capacity to respond in terms of speed. Computer resource sharing is not a new development. However, in most cases, this is thought of only in terms of sharing processing or memory. On-line developments, which need not necessarily be time-shared, are opening up cooperative and remote use of programs which are locally developed. This avoids the expensive process of duplicating the computer programs in several locations. The communication circuit requirements are of the two-way point-to-point type. Data rate requirements for the circuit could be symmetrical as well as asymmetrical depending upon the particular system configuration. Data rate requirements depend upon whether interaction is taking place at "electro-mechanical" speeds or is occurring at "electronic" speeds. Data terminals operating at electro-mechanical

speeds include line-impact printers, card punch/readers, paper tape punch/readers, and mechanical digital plotters. Data terminals operating at electronic speeds include buffered magnetic tape drives, magnetic disc drives, non-impact printers, graphic CRT and computer based terminals. Transmission requirements could be as high as 50 kilobits/second for the type of systems that are in use today.

Among the potential educational uses for these services are:

1. Primary and Secondary School Instruction
2. Instruction and Research in Institutions of Higher Learning
3. Vocational Education
4. Inter-Library Services for Resource Sharing and Remote Information Retrieval
5. Continuing Education (Adults/Professionals)
6. Public Television and Radio
7. Special Television Services
8. Educational Administration

Figure 2 graphically depicts the possibilities.

In the following section, we will summarize the results of seven discrete investigations which examine some of the problems and possibilities, and which serve as a data base for the Needs Analysis. This will be followed by a bringing together of this information in a coherent way to estimate ranges of utilization for several of these services for the purpose of systems synthesis.

II.B. EDUCATIONAL ELECTRONIC INFORMATION DISSEMINATION AND BROADCAST SERVICES

1. Introduction

A study has been conducted by J. P. Singh and R. P. Morgan on electronic educational information dissemination and broadcast services in the United States*.^[3] Included are detailed discussions of the historical development and current infrastructure, both in terms of organization

*The Sections of this Progress Report which summarize the results of Memoranda do not contain References. The reader is referred to the individual memoranda themselves for details.

	Public Television (PTV)	Instructional Television (ITV)	Computer-Assisted Instruction (CAI)	Remote Batch Processing	Interactive Multi-Access Computing	Inter-Library Communication	Interactive Information Retrieval	Teleconferencing
Elementary Schools		[I,C]	[I,C]	[A]	[A,I]		[C]	
Secondary Schools		[I,C]	[I,C]	[A,I]	[A,I]		[C,I]	
Institutions of Higher Education		[I,C]	[I]	[A,I,R]	[A,I,R]	[R]	[C,I,R]	[A,I,R]
Vocational Education		[I]	[I]					
Community Learning Centers	[G]	[C,I]	[C,I]		[C,I]		[C,I]	[C,I]
Homes	[G]	[C]	[C]				[C,G]	[C,G]

A = Administrative Uses
 C = Continuing Education and/or Formal out-of-school Education
 G = General Information and/or Educational, Cultural Entertainment
 I = In-School Instruction
 R = Research Applications.

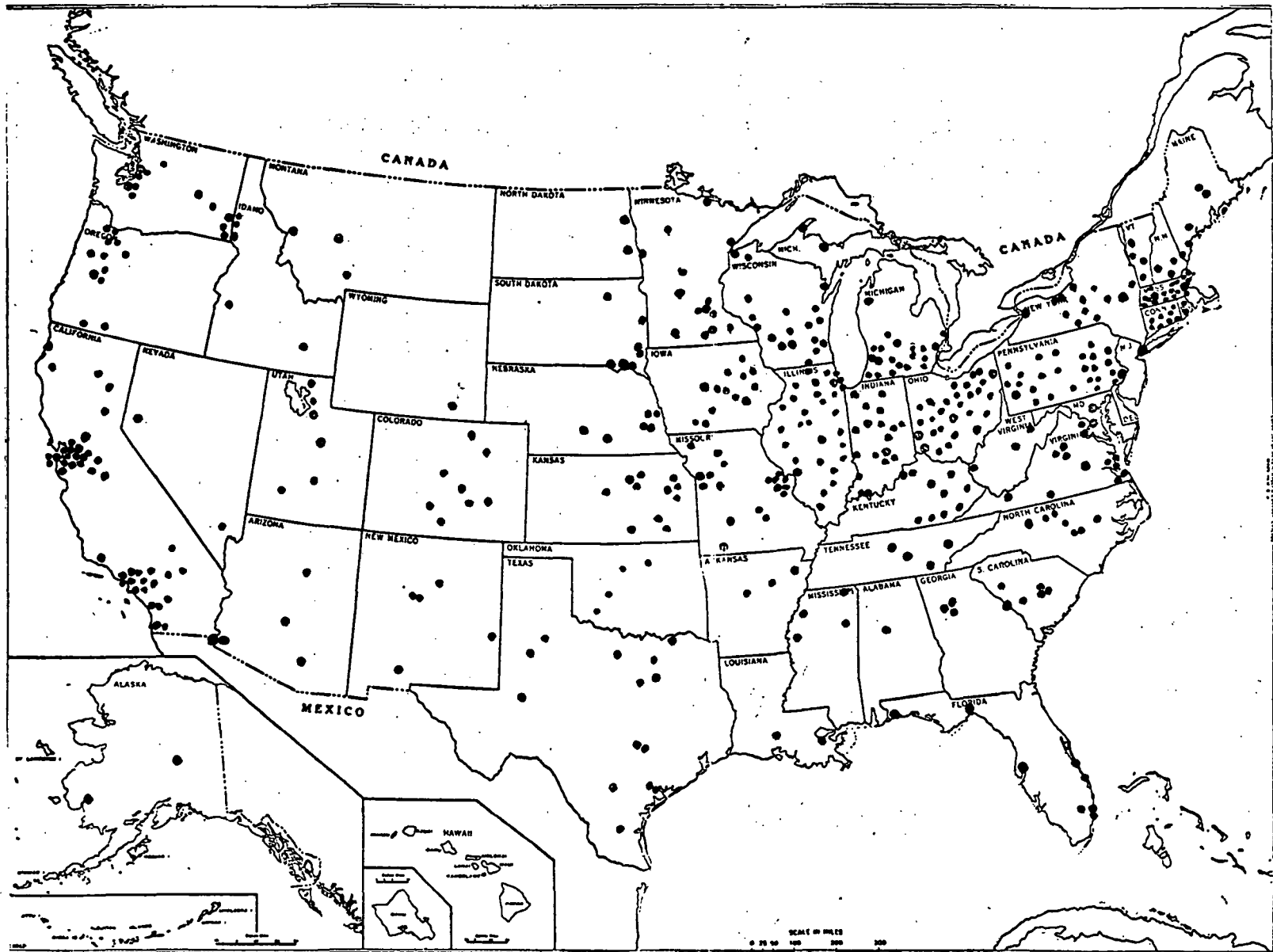
Figure 2. Educational Telecommunications Service Applications

and physical plant, of the following services: Educational Radio Broadcasting, Educational Television Broadcasting, Instructional Television Fixed Services (ITFS), Information Retrieval Television (IRTV), Closed-Circuit Television, Responsive Television and Cable Television. All of the information dissemination and broadcast services described herein can currently be characterized as providing one-way transfer of information on a point-to-multipoint basis with the population of the receiving terminals being independent of the transmitter or origination point within the coverage area.

In the United States, a variety of electronic educational information dissemination and broadcast services have developed, reflecting the local character of U.S. education and a lack of resources and organization vis-a-vis commercial broadcasting. A series of maps have been plotted (See Figures 3-8) which indicate that these services, which include both intra- and inter-state television networks, are not distributed uniformly over the entire U.S. Certain areas--such as Alaska, the Rocky Mountain States and to some extent Appalachia--generally characterized as remote or rural areas, tend to have a dearth of services.

2. Educational Radio

Educational radio broadcasting has grown since 1938 when the Federal Communications Commission established a new class of stations known as "noncommercial educational" stations. This growth accelerated with the advent of FM broadcasting in the late 1940's but has been overshadowed by the growth of television. As of December 1970, there were 457 educational radio stations in the U.S. However, approximately half of these stations are "Class D" stations limited to 10 watt transmitter power-output. The dominant group (71%) of licensees is the colleges and universities and programming is for primarily cultural enrichment, student and extension training. Recently the Corporation for Public Broadcasting has established a set of criteria for public educational radio stations. Only 92 of 457 stations meet the necessary transmitter power and minimum staff and operational requirements. These 92 stations have been brought together under the rubric of National Public Radio (NPR) (See Figure 4). NPR has recently initiated an interconnection of its facilities using AT&T facilities, a



DISTRIBUTION OF EDUCATIONAL RADIO STATIONS

Figure 3

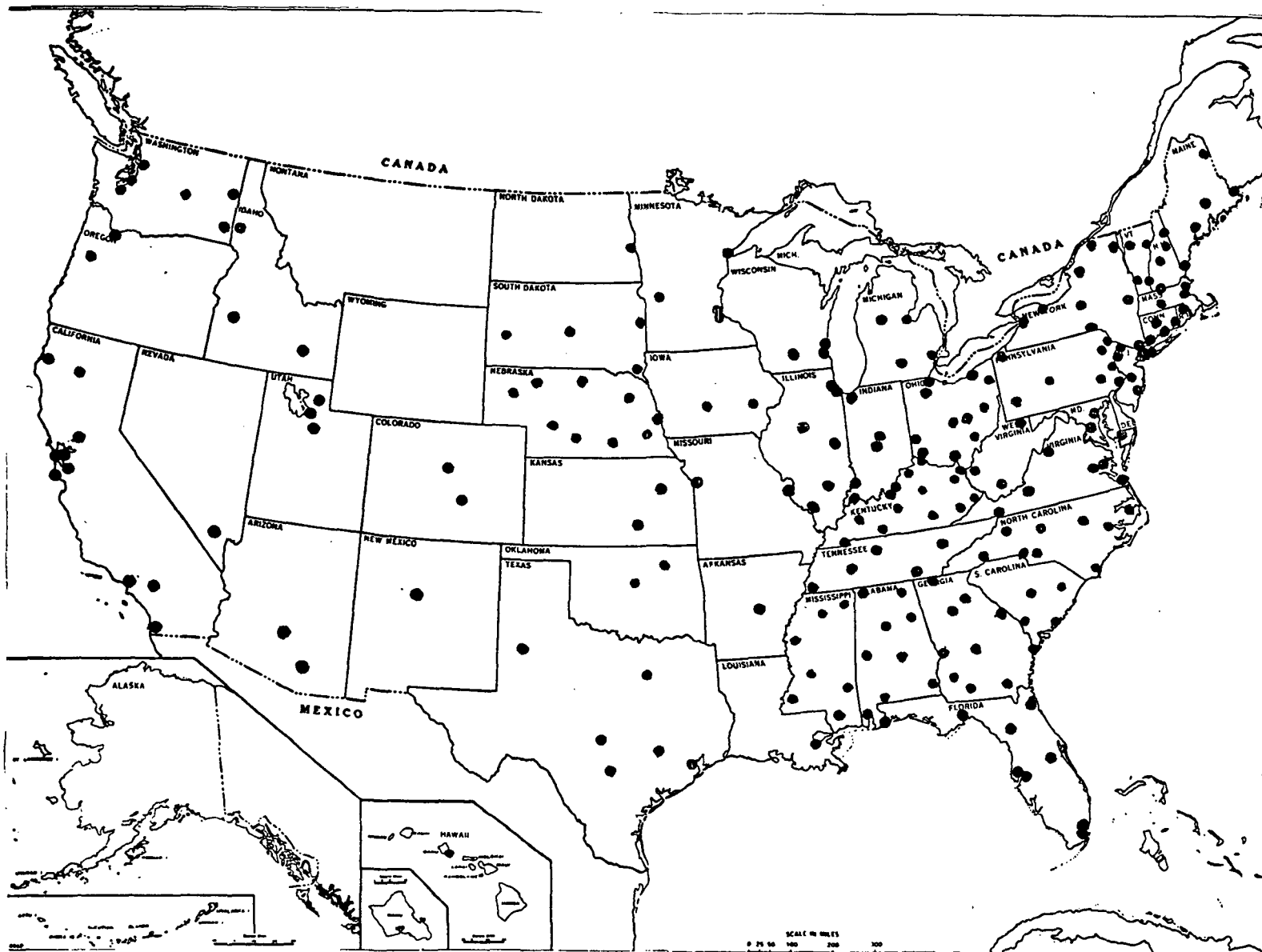
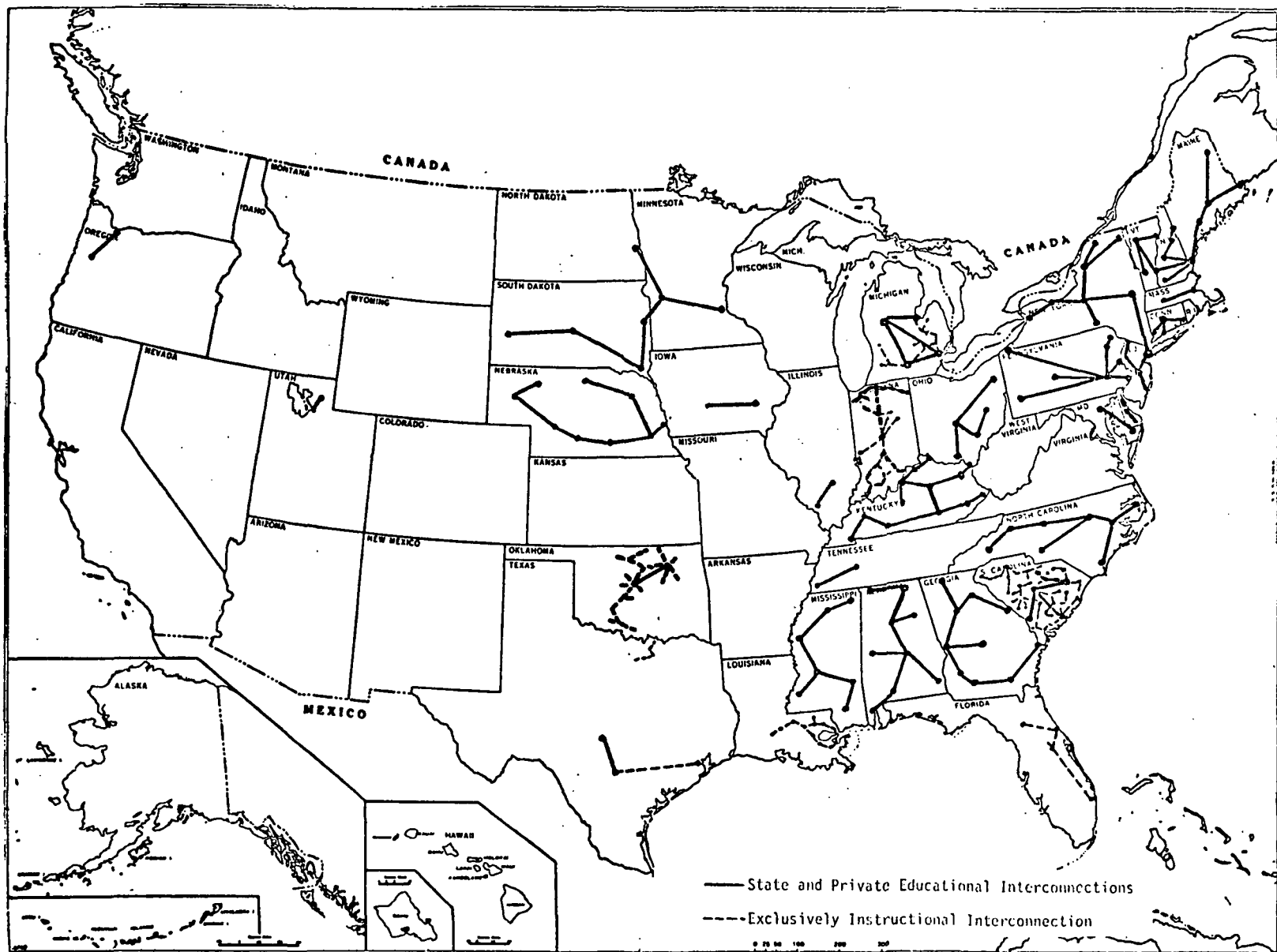
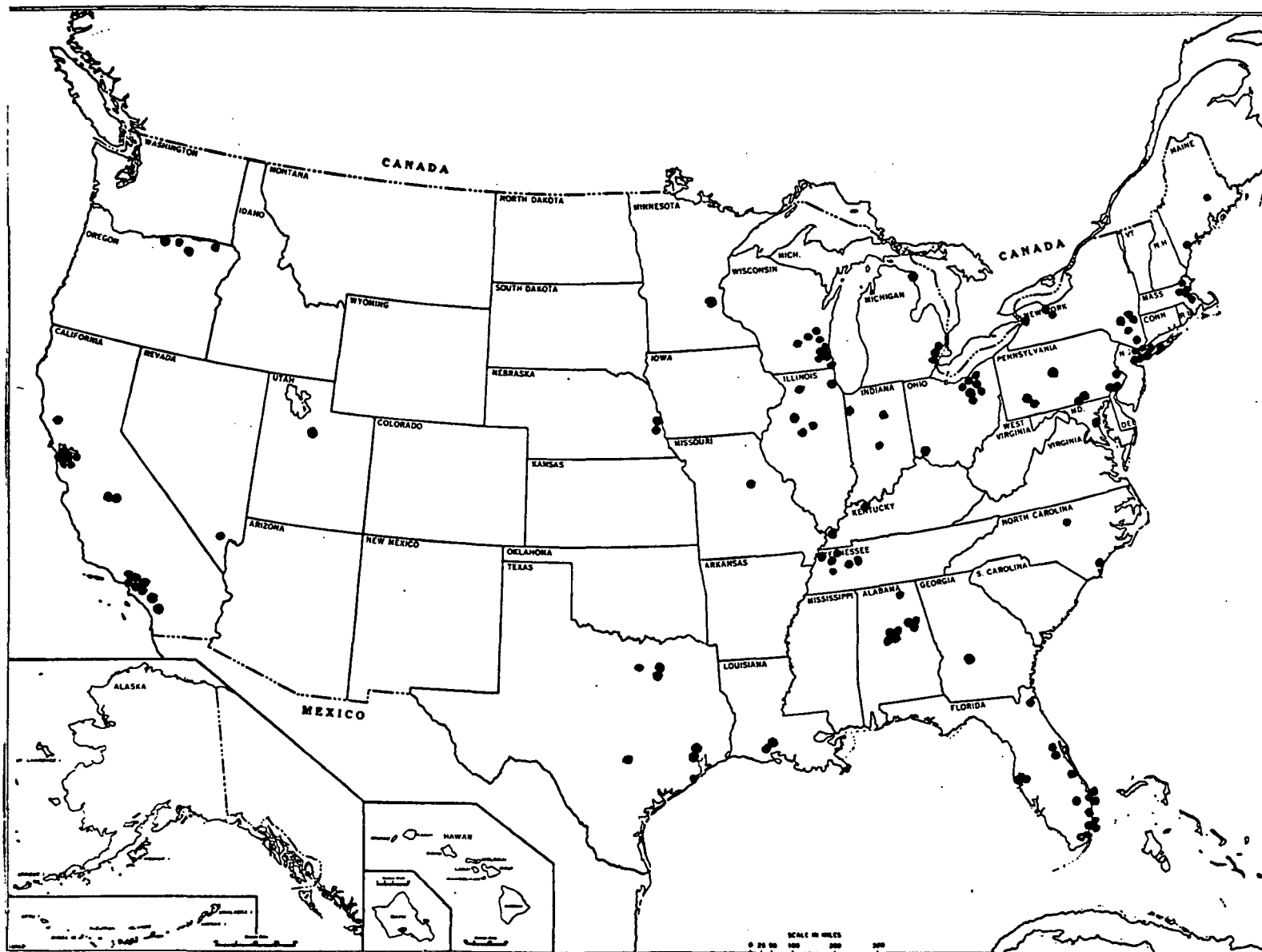


Figure 5. DISTRIBUTION OF EDUCATIONAL TELEVISION STATIONS



INTER- AND INTRA-STATE EDUCATIONAL COMMUNICATION NETWORKS

Figure 6



DISTRIBUTION OF ITFS INSTALLATIONS

Figure 7

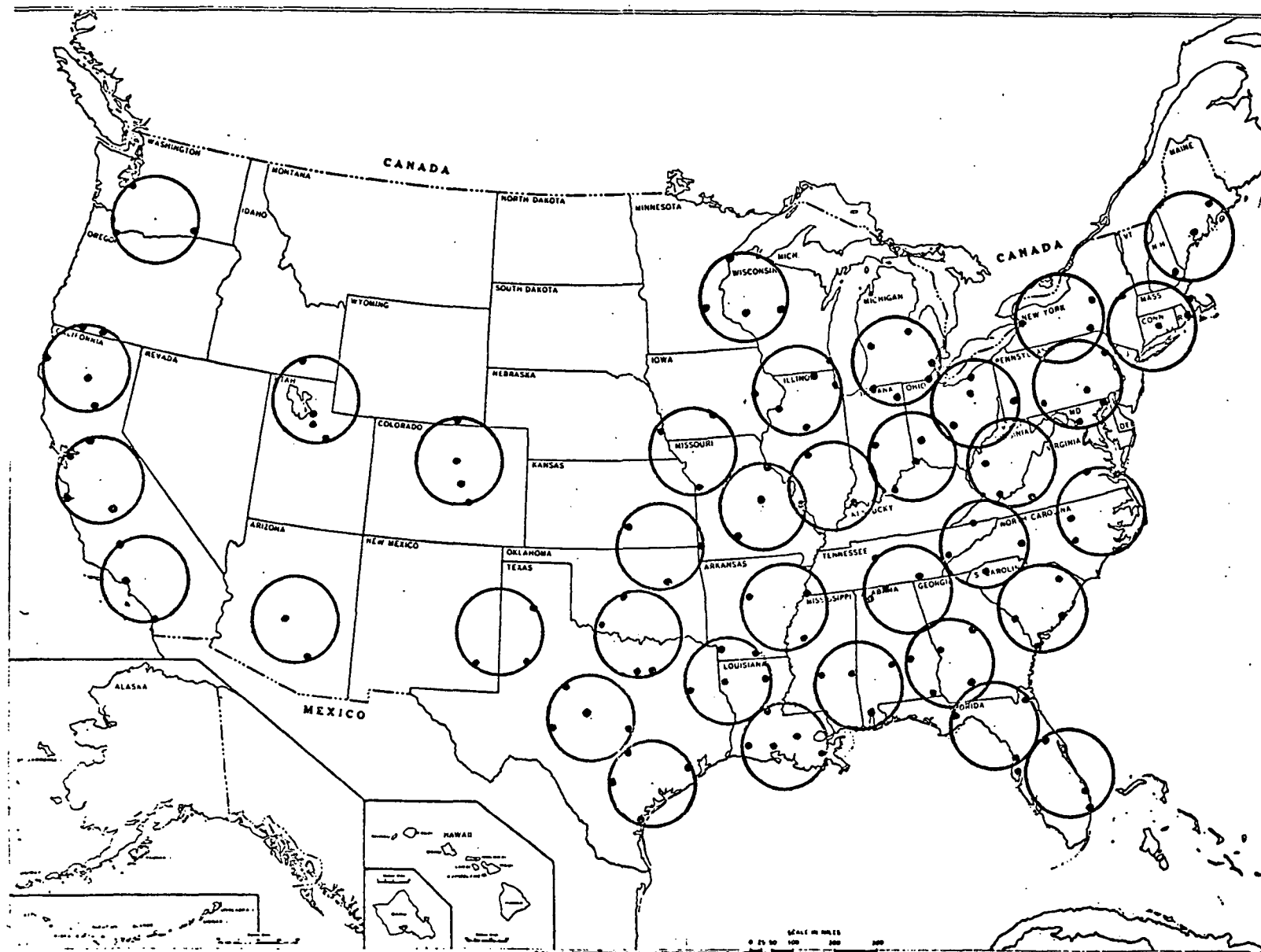


Figure 8. PROJECTED CATV SERVICE AREAS IN 1975

library service and an expansion in the number of members to an estimated 137 transmitters by the end of 1971. They have been involved in planning experimental satellite interconnection of members in Alaska and Puerto Rico.

3. Educational Television

Educational television in the U.S. has grown to the current level of 204 ETV outlets on the air compared with 140 in 1967 and 62 in 1962. Another 6-10 are under construction. Of the 204 stations, some 43% are licensed to state and local educational systems, 32% to universities and colleges and the remainder to community organizations. Most ETV stations are located in the densely populated areas, especially in the eastern part of the country. Some 74% of the U.S. population is capable of receiving ETV signals. Large areas of the central and western states do not have any ETV coverage (See Figure 5).

As far as ETV program content is concerned, the programs broadcast depend upon station ownership and operation. Stations licensed to school systems are primarily involved with instructional programming whereas stations licensed to state agencies divide their program time between public and in-school instructional offerings. University owned stations are primarily oriented towards public television programming as are the community owned stations.

Recent years have seen the development of production and distribution organizations which are national in scope. Program production centers such as NET have been joined by the Public Broadcasting Service which serves to select, schedule, promote and distribute national programs to noncommercial ETV stations. Currently PBS is operating an interconnection service feeding some 25 hours/week of programming to its affiliates via AT&T facilities. Some 140 ETV stations are interconnected for live distribution at scheduled times. In addition to the national PTV network (PBS), there are several regional and state networks in operation (See Figure 6). The relation between the regional networks and PBS is discussed in the report.^[3] Some 15 states have intra-state ETV networks, 9 of which are state owned. A recent PBS survey pinpoints the location and characteristics of these networks.

Instructional television does not have the national base that public broadcasting has through PBS. There are instructional TV distribution centers such as NIT, GPNITL and MPATI, but the local nature of education has worked against a national construct. Programs such as Sesame Street and The Electric Company, although primarily designed for out-of-school use may bring about greater interest on the part of PBS in instructional television. The U.S. Office of Education has also shown a strong interest in educational telecommunications.

4. Other Distribution Modes (CCTV, ITFS, Cable Television)

The study surveys both Closed-Circuit Television (CCTV) and the Instructional Television Fixed Service (ITFS).^[3] The last comprehensive survey of CCTV was carried out in 1967. Data is hard to come by because of the wide variety of equipment and facilities which can be defined as CCTV. However, it is believed that there has been a rapid growth since the 812 installations reported in 1967, with use divided almost evenly between higher education on one hand and elementary and secondary education on the other, and with a large local production component. The minimum requirement for being counted as a CCTV facility in the 1967 NEA survey was a VTR, TV monitor and camera. Some 21% of 17,000 schools are now reported to own both VTR's and TV sets.

As of September 1970, there were some 157 ITFS systems totaling 556 channels. Approximately one-third are owned by religious organizations and are used for instruction in parochial school systems. The bulk of the remainder evenly divide between universities, school districts, and county ownership. In general, ITFS has been used solely to distribute instructional TV material to traditional classroom situations, with very little application for computer-communications, data transmission or educational administration. A number of instructional networks have come into being, particularly at the higher education level, which make use of CCTV and ITFS such as the GENESYS and TAGER systems.

An important development which may affect the local distribution of electronic educational media is the growth of CATV or cable television. In 1950, there were only 5 such installations but by 1953, there were almost 300 systems and today, this number has grown to over 2400 serving more than 5 million TV households out of a total of 62 million. Although

originated solely for the purpose of providing access to distant TV channels in order to achieve greater program diversity and improved reception, cable-TV is now being installed in major cities and is being contemplated for use in providing a wide spectrum of services (See Table 2) in the so-called "wired-city" or "Broad-Band Communications Network". One important reason for the interest in and growth of cable TV is the large channel capacity of this "non-radiating" medium in which 20 to 40 TV equivalent channels are coming into being. These channels do not consume over-the-air frequency spectrum and therefore are not liable to cause interference to other neighboring services operating in the same frequency band.

The educational potential of cable-TV has been recognized and is just beginning to be exploited. Recent FCC decisions and the efforts of groups such as SCOPE are likely to spur educational utilization. A recent study by Barnett and Denzau of our study team highlights the potential benefits of a dedicated educational 40 channel cable system interconnecting schools and allowing flexibility in use through repetitive program transmission (See Section IVD). A recent proposal by Hughes Aircraft to the FCC contemplates interconnecting cable-TV headends via satellite. The CATV-satellite combination offers a potential solution for a second nationwide ETV service which otherwise would be impossible to implement on a nationwide basis due to the scarcity of second ETV broadcast channel allocations in most areas.

5. Requirements for Public Television and Radio

Public television and radio, representing one segment of electronic educational information dissemination and broadcast services, have in recent years developed a national organizational and networking base as well as goals for nationwide coverage. The creation of the Corporation for Public Broadcasting, the Public Broadcasting Service and National Public Radio have made it possible to develop this capability. These organizations have set forth their requirements in response to the recent filing of proposals with the Federal Communications Commission by eight organizations for owning and operating U.S. domestic satellite systems. After reviewing these requirements, and after considering key issues such as regional versus national versus special programming, we have set forth potential long-haul telecommunications requirements for public television

Table 2

POTENTIAL CATV/ WIRED CITY/ BROADBAND COMMUNICATION SYSTEM SERVICES

HOUSEHOLD	BUSINESS	SCHOOLS	GENERAL PUBLIC
POLICE, FIRE AND MEDICAL HELP SIGNALS	CCTV	CCTV	TRAFFIC SURVEILLANCE
TELEMETERING - GAS, WATER AND ELECTRICITY METER	DATA RETRIEVAL	PUBLIC RADIO & TV	TRAFFIC SIGNAL CONTROL
	COMPUTER TIME-SHARING	COMPUTER TIME-SHARING	FIRE AND CRIME SURVEILLANCE
BANKING	FACSIMILE MAIL AND NEWS	COMPUTER BASED INSTRUCTION	POLLUTION SURVEILLANCE
ELECTRONIC MAIL	DATA TRANSMISSION	DATA RETRIEVAL	
CONSUMER INQUIRY	CONTINUOUS BUSINESS NEWS - STOCK MARKET SITUATION ETC.	INFORMATION RETRIEVAL TV	
SHOPPING	CUSTOMER SALES	IMPLEMENTATION OF AN EDUCATIONAL INFORMATION SYSTEM (EIS) FOR IMPROVED EDUCATIONAL MANAGEMENT	
CONTINUOUS NEWS, WEATHER AND BUSINESS INFO.	TELEMETERING		
FACSIMILE NEWSPAPERS	POLICE AND FIRE SIGNALS		
PAY TELEVISION			
LARGE NUMBER OF TV AND RADIO PROGRAMS			

and radio distribution. An analysis of key features of the eight U.S. domestic satellite proposals and comments on the suitability of these proposals for meeting the requirements of public broadcasting is included in Section IV.B.

PBS has specified its requirements for a satellite distribution service as two full-time, non-preemptible channels with adequate backup for sun outage, eclipse operation and potential transponder failure. These channels will permit PBS to deliver a national programming service providing one single package to the Eastern and Central time-zones and another package, similar to the previous one but displaced in time by three hours, for the West Coast, i.e. Pacific time-zone (See Figure 9). The Mountain states will be served by a local delay center at Denver and through the terrestrial facilities leased by the Rocky Mountain Public Broadcasting Network (RMPBN). NPR has stated similar requirements for the public radio, i.e. a time-delayed package for the Western time-zones.

In addition to these channels, primarily needed between 6 A.M. to 12 P.M. local standard time, public broadcasting will also require distribution facilities on a part-time and occasional basis. PBS estimates that some 31 hours per week will be required for regional programming, special time-delays, and program assembly. Currently, the PBS network splits into five regional networks for one hour per week of prime time regional programming. However, PBS can schedule the network split to reduce its maximum requirement to one additional channel hour per day, five days per week.

In addition to provision for regional splits, special time-delays in the two time-zones not delayed by the basic service would be needed to accommodate supplemental type instructional programming such as Sesame Street and its new reading program follow-up within local school schedules. PBS has estimated its requirements for special time-delays as two additional hours per day for five days per week. PBS and its member stations are developing an expanded series of public affairs programs that would draw on member stations. To permit program assembly, part-time access to a channel will be required. PBS estimates that it would require some two hours per day, seven days a week, with two extra hours on Fridays. Also, there is a need for occasional access to a satellite channel for

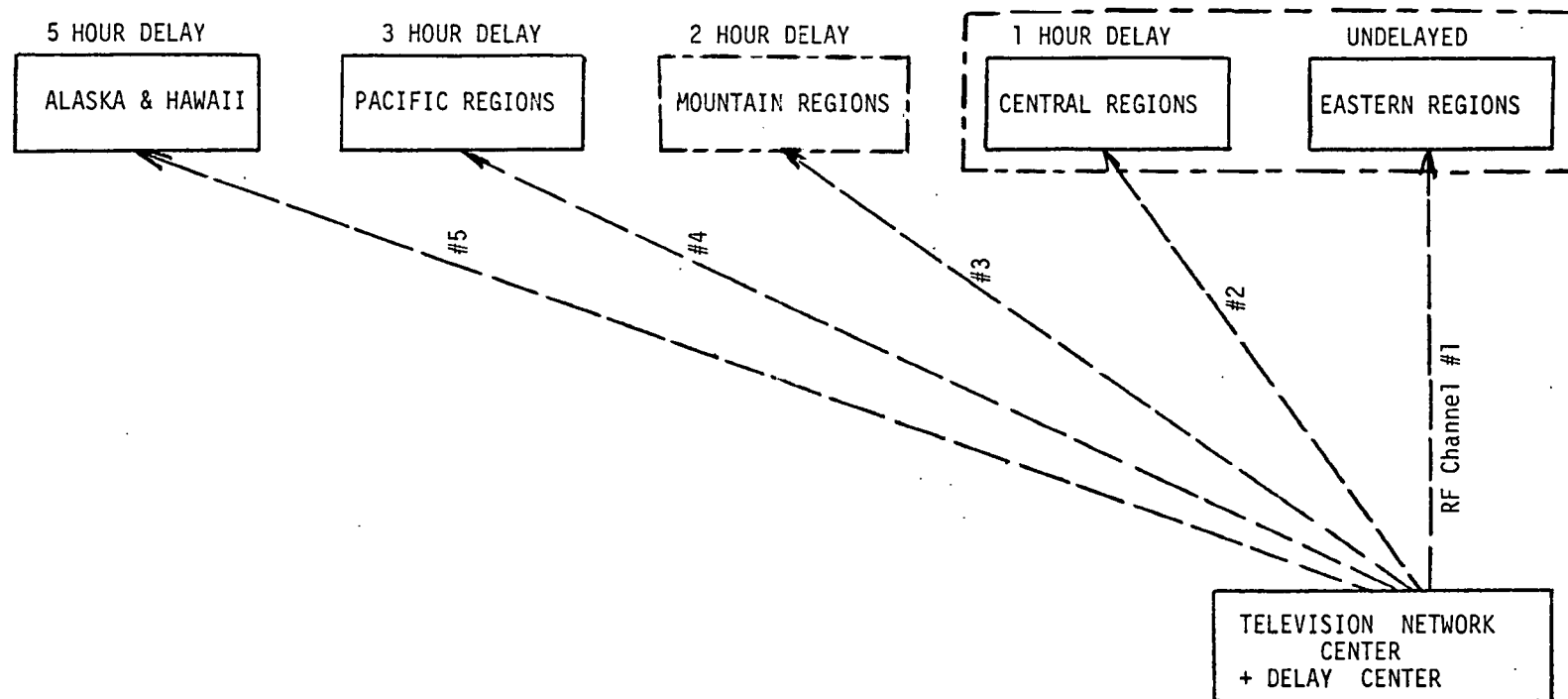


Figure 9 . TIME-ZONE OPERATION BY SATELLITE LINKS

covering unexpected special events that cannot be accommodated within the full-time or supplemental services described above.

So far, the requirements have been discussed in terms of "channels". Now it becomes necessary to specify the channel bandwidth, special provision such as order wire and stereo sound, picture quality, etc. For television networking and program distribution purposes, the "channel" would consist of a 4.2 MHz standard video channel, an order wire for supervisory and control purposes and two 15 kHz sound channels to provide stereophonic sound. PBS has listed stereo sound with a standard video channel as a requirement. The authors agree with this requirement from the long-term point of view. As far as the radio "channel" is concerned, it is composed of two 15 kHz channels to provide stereophonic capability. Though NPR has not mentioned any need for an order wire facility, the authors feel that an accompanying order wire facility would be desirable, in view of the nature of the NPR networking design which is much different than those of commercial radio networks. Three kHz audio channels would suffice as "order wires" for both TV and radio "channels".

Currently radio networking and TV networking is limited to rather low quality audio based on 3.5 kHz to 5 kHz wide channels due to the unavailability of high quality long-distance terrestrial facilities for audio. NPR presently pre-records high quality and stereophonic programs and distributes them by mail. However, satellites offer a distinct possibility for distribution of high quality (15 kHz) stereophonic audio signals and would permit real-time transmission of such programs. Tables 3 and 4 summarize Public Television and Public Radio Service Requirements. Figure 10 shows the proposed PBS television origination points.

The Federal Communications Commission in its Report and Order, in the matter of Domestic Communication Satellite Systems (Docket 16495), adopted on March 20, 1970, declared that applicants proposing multipurpose domestic communications satellite systems should discuss the terms and conditions under which satellite channels will be made available for noncommercial broadcast networks, if the applicants' proposed service includes commercial television and radio program distribution. March 15, 1971 was the last date for submission of proposals to the FCC. Eight separate proposals have been filed with the FCC by a combination of

Table 3

PUBLIC TELEVISION SERVICE

SOURCES

PUBLIC BROADCASTING SERVICE (PBS)
EASTERN EDUCATIONAL TELEVISION NETWORK (EETN)
CENTRAL EDUCATIONAL NETWORK (CEN)
SOUTHERN EDUCATIONAL COMMUNICATIONS ASSOCIATION (SECA)
MIDWESTERN EDUCATIONAL TELEVISION (MET)
ROCKY MOUNTAIN PUBLIC BROADCASTING NETWORK (RMPBN)
WESTERN EDUCATIONAL NETWORK (WEN)
NATIONAL EDUCATIONAL TELEVISION (NET)
CHILDRENS TELEVISION WORKSHOP (CTW)

DESTINATIONS

207 PTV/ITV STATIONS FOR REDIFFUSION VIA 109 FEED POINTS; ADDITIONAL 98 TO BE FED THROUGH STATE NETWORKS.

CABLE TELEVISION (CATV) HEADENDS.

COMMUNITY AND SCHOOL RECEIVERS THROUGH DIRECT DISTRIBUTION/BROADCASTING FROM SATELLITE(S) IN REMOTE AREAS OF ALASKA, MOUNTAIN STATES AND APPALACHIA WHICH DO NOT HAVE ACCESS TO ANY ETV SERVICE.

SYSTEM REQUIREMENTS

(A) PROGRAM DISTRIBUTION

- 50 STATE COVERAGE
- NATIONAL AND SUB-NATIONAL DISTRIBUTION PROVISIONS
- DELAYED PROGRAMMING FOR PACIFIC AND MOUNTAIN TIME-ZONES
- PROVISION FOR MULTIPLE POINT ORIGINATIONS
- PROVISION OF AN ORDER WIRE FOR EACH CHANNEL
- PROVISION OF PART TIME USE OF ADDITIONAL CHANNELS FOR SPECIAL EVENT COVERAGE, SPECIAL TIME-ZONE DELAYS, PROGRAM ASSEMBLY, REGIONAL SPLITS ETC. IN ADDITION TO TWO SATELLITE CHANNELS DURING 0600-2400 HRS EVERY DAY.
- TWO 15-KHz SOUND CHANNELS FOR STEREOPHONIC SOUND
- SPACE LINK CONFORMING TO CCIR RECOMMENDATIONS, i.e. A SNR OF 55 dB

(B) DIRECT DISTRIBUTION TO COMMUNITY INSTALLATIONS

- SUB-NATIONAL COVERAGE - ALASKA, ROCKY MOUNTAINS AND APPALACHIA
- SEPARATE CHANNEL FOR EACH AREA
- PROVISION FOR NATIONAL AS WELL AS REGIONAL PROGRAM ORIGINATION
- PROVISION FOR PART-TIME USE OF ADDITIONAL CHANNELS FOR EVENINGS AND WEEKENDS
- ONE 15-KHz SOUND CHANNEL FOR MONOPHONIC SOUND
- SPACE LINK WITH A SNR OF 43.5 dB TO PROVIDE TASI GRADE 2 SIGNAL

Table 4

PUBLIC RADIO SERVICE

SOURCES

NATIONAL PUBLIC RADIO (NPR)
NATIONAL EDUCATIONAL RADIO NETWORK (NERN)
REGIONAL RADIO NETWORKS
(CURRENTLY UNDER DEVELOPMENT)

DESTINATIONS

92 MAJOR EDUCATIONAL RADIO STATIONS
CATV HEADENDS
COMMUNITY AND SCHOOL RECEIVERS, LOW POWER
REBROADCAST TRANSMITTERS THROUGH DIRECT
SATELLITE DISTRIBUTION/BROADCASTING IN
REMOTE AREAS OF ALASKA, MOUNTAIN STATES
AND APPALACHIA WHICH DO NOT HAVE ACCESS
TO ANY ER SERVICE.

SYSTEM REQUIREMENTS

(A) PROGRAM DISTRIBUTION

- 50 STATE COVERAGE
- NATIONAL AND SUB-NATIONAL PROGRAM DISTRIBUTION PROVISION
- PROVISION FOR MULTIPLE POINT ORIGINATIONS
- DELAYED PROGRAMMING FOR MOUNTAIN AND PACIFIC TIME-ZONES
- PROVISION OF A 3.5 kHz ORDER WIRE WITH EACH OF THE TWO "CHANNELS" CONSISTING OF TWO 15-KHz AUDIO CHANNELS FOR STEREOPHONIC SOUND
- PROVISION FOR PART TIME USE OF ADDITIONAL CHANNELS FOR REGIONAL SPLIT, PROGRAM ASSEMBLY AND SPECIAL EVENT COVERAGE
- SPACE LINK WITH A SIGNAL TO NOISE RATIO OF 50 dB

(B) DIRECT DISTRIBUTION TO COMMUNITY INSTALLATIONS

- SUB-NATIONAL COVERAGE - ALASKA, ROCKY MOUNTAINS AND APPALACHIA
- SEPARATE CHANNEL FOR EACH AREA
- PROVISION FOR REGIONAL AS WELL AS NATIONAL MULTI-POINT PROGRAM ORIGINATIONS
- A CHANNEL-WIDTH OF 15 kHz
- SPACE LINK WITH A SNR OF 43 dB

aerospace companies and common carriers for authorizations to construct domestic satellite facilities.

Many of the proposals fail to satisfy the requirements set forth by PBS. The Hughes Aircraft proposal contemplates placing satellites so that they can not "see" the entire U.S. Only the Fairchild Hiller proposal specifies the use of the 2.5 GHz downlink frequency which seems attractive for educational use. All proposals fail to satisfy the multiple point program originations specified by PBS and none of them contemplate order wire and stereophonic high fidelity channels accompanying the video signal. This subject is discussed in more detail in Section IV of this report.

II.C. INSTRUCTIONAL TELEVISION UTILIZATION IN THE UNITED STATES

1. Introduction

A study has been performed by J. R. DuMolin which summarizes and evaluates various aspects of utilizing instructional television and develops basic guidelines for future utilization of television as an instructional medium in education.^[4] The DuMolin report is divided into four sections. The first discusses the role of technology in education, outlines the capabilities and limitations of television as an instructional medium and briefly reviews the state of ITV research efforts. Section Two is designed to familiarize the reader with examples of various ongoing ITV programs, and to summarize the possibilities inherent in instructional television. Section Three deals with the problems involved in the three stages of the ITV process; production, distribution and classroom utilization, which are necessary to deliver instructional programming to the student via television. Section Four is a summary analysis which outlines probable trends in future utilization. Mr. DuMolin's summary of his work is included in the following sections.

2. Instructional Television: A Technology in Education. The Development Programs.

Technology, in itself, is neither good nor bad but it is the manner in which it is applied which determines its value. Instructional media, and its major component television, has not yet had a significant impact

on the instructional process. In reviewing the literature it becomes clear that, with a few exceptions, most of the research in instructional media has been fragmented with little coordination between the research projects and those people in the development stage who are producing software and using it in the classrooms. To understand utilization one must examine "development programs," i.e., programs involving ongoing instructional projects as a separate area.

After reviewing on-going programs it becomes obvious that television can be and is used to meet a wide spectrum of both formal and informal educational needs. The Sesame Street and Appalachia Educational Laboratory programs demonstrate not only television's instructional potentials but also its ability to cut across the barriers of social status, poverty and racial prejudice to ease disparities in educational opportunity.

On the elementary and secondary levels, television cannot only raise the quality of instruction but also serve as an agent of change to promote improved administration and teaching methods and better utilization of physical resources. In terms of higher education, the effects of television have brought about substantial savings in cost and extended the range and influence of the university beyond the campus into the community. The flexibility of the television medium is demonstrated by its ability to facilitate communications within the community, stimulate interest and action on local problems, and even promote two-way dialogue between community groups and the experts capable of giving them leadership.

The question must now be asked that if television's potential as an instructional tool is so great and if it has the capability of reaching beyond traditional educational barriers, why then in its almost two decades of existence has it had only a marginal impact on the educational structure and institutions of this nation? The failure of American education, as a whole, to accept, utilize, and optimize this new technology is a complex problem which must be understood if our educational systems are to meet the rising demands placed upon them by society's need for better educated and informed individuals.

3. Utilization of and Resistance to Instructional Television

a. The Production Phase

It appears that it is not the television itself but also, in part, the quality of the material presented which determines utilization. Poor programming is "turned off" by students and shunned by teachers. School systems have generally found it almost impossible, both financially and administratively, to produce quality material in enough quantity to meet their needs. When institutions try to expand their range of programming they are blocked on the commercial level by high cost and poor quality. Due to complex copyright laws which demand permission from the film clip dealers before clips can be transferred and the lack of standard policies among dealers concerning fees, utilization rights, editing and dubbing, any large scale exchange of programming between school districts is both time consuming and expensive.

The use of different types of recording equipment during the production stage has made compatibility of materials a serious problem at the utilization phase. This often prevents program-sharing between institutions and is expensive in that it reinforces uneconomical local production.

b. The Distribution Phase

Administrative, pedagogical, and time scheduling problems all act upon the choice of the proper ITV distribution system. Channel capacity is limited for VHF/UHF transmission. ITFS is being used to increase channel capacity but advancements in multi-channel cable systems appear to make cable a primary distribution system for urban and suburban areas in the future. Teachers appear favorable to using video tape recorders to help solve scheduling problems. However, a severe shortage of TV receivers appears to be a major barrier to increased utilization.

c. The Classroom Utilization Phase

In evaluating the statistical impact of ITV, reliable data is in short supply because of contradictory and misleading methods used to collect utilization statistics. It is predicted that by 1975 one of every four students from K-12 in the U.S. will be using television as a part of his instructional format. However, this does not mean that

ITV will play an important role in instruction. In 1967 utilization was on the average less than 3% of classroom time (See Table 5). The reasons for this underutilization vary from lack of funds to train teachers in the principles of ITV use to strong teacher resistance due to uncertainty as to the proper role television will play in the learning. In addition, the general public still questions the utility of using a television, which generally is thought of as an entertainment medium, for instructional purposes.

4. A Summary Analysis and Outline of Probable Trends in ITV Utilization

a. Programming

First, let us assume that the major block to meaningful ITV utilization, as determined by teacher attitude surveys, etc., is the lack of enough high quality programming to maintain continuous use of the television medium as part of the everyday curriculum. This assumption places the blame for underutilization of ITV on the production phase. In the past, fragmented local production of materials has prevented extensive use of the medium. However, a steady trend, especially for VHF/UHF stations, has reduced the level of local production from 77.9% of the hours broadcast in 1962, to only 27.2% in 1970. From the period of 1968 to 1970 ITFS and CCTV have reduced local programming from 57.9% and 72.4% of their broadcast time to 42.1% and 54.6%, respectively. This broad reduction in local production is due to increased utilization of national and regional production and distribution sources such as NIT, GPITL, and MPATI. The sharper drop by VHF/UHF stations can be attributed to the continuing effort of the Public Broadcasting Service to interconnect and supply community ETV stations with quality programming. While ITFS and CCTV show marked reductions in local programming, they are primarily instructional systems which have specific local subject requirements which still rely heavily on local production. More extensive use of national sources and program exchanges with other institutions is blocked by copyright problems, a lack of universal technical standards, and the high duplicating and mailing cost of video tapes.

TABLE 5
 PERCENTAGE OF TOTAL SCHOOL HOURS
 FOR WHICH INSTRUCTIONAL TELEVISION IS AVAILABLE*
 (K-12)

Baltimore	.67%
Boston	1.19%
Buffalo	1.94%
Chicago	3.03%
Cleveland	2.26%
Detroit	10.00%
Los Angeles	1.83%
Memphis	3.08%
Milwaukee	1.83%
New York	2.02%
Philadelphia	4.29%
Pittsburgh	2.34%
San Diego**	2.31%
San Francisco	2.41%
St. Louis	2.86%
Washington, D.C.	-----

*From Benton, C.W. et.al., "Television in Urban Education", Praeger, N.Y., 1967

**Telecasts began in February, 1967

The problems involved in local production have led many to suggest the establishment of large scale national or regional centers for the production of high quality instructional programs. They feel that only through national centers can enough quality material be generated to satisfy the diverse needs of the U.S. educational system. However, it is not enough to just produce large amounts of programming. Simultaneous changes in legal and technical areas must accompany production increases. A reassessment of the copyright laws must be made to determine reasonable fees for materials produced and distributed on a national level. Standards must be set for policies concerning the editing and dubbing of nationally distributed materials by teachers at the local level. In addition, standardization of all production, reception, and playback equipment is desirable to assure universal compatibility of materials.

Even if large scale national production does become a reality along with the necessary legal and technical adaptations, there will still be considerable resistance to placing production of material for such a powerful communication medium under centralized control. Funding for such a production center would of necessity have to come in part from some federal source, especially if programming is to meet the quality and quantity estimates discussed in the report.^[4] The use of federal money is, in the minds of many educators, synonymous with federal control. The idea of having a single authority, responsible to the federal government, determining the instructional content of a major educational resource is unthinkable to many local, county, and state politicians.

One possible factor which may counter the trend towards national production is the rapid development of low cost video recorder systems. For as little as \$1500, a complete porta-pack VTR, camera, and monitor can equip the smallest school with a basic CCTV production system. Advances in video recorder/playback systems are making it possible to take production out of the expensive centralized ITV studies and putting it in the hands of local teachers and students to decentralize production to meet local needs. Where this trend will lead and to what extent it will counter moves toward centralization is difficult to predict.

b. Distribution

In contrast to those who feel that ITV's major problem is one of production, there are those who believe that there is at present a large body of quality programming, both educationally and commercially produced, suitable for ITV if some economic and efficient distribution method can be found. Most institutions which use national and state sources for programming are forced to use the expensive and time consuming public mails to borrow or rent video tapes. It appears that the electronic linkage of schools to district centers, and district centers to regional or national program sources is the solution to the distribution problem.

Of the various electronic methods now in use; VHF/UHF, ITFS and CCTV, CCTV cable distribution now appears to be the most promising for urban and suburban distribution between schools and district centers. Recent decisions by the FCC ordering cable operators to expand community oriented services have given educators access to cable distribution systems at minimal or no cost. However this "piggy back" access is generally limited to only a few channels and only in those areas where cable systems are in operation.

More important is a current study by Barnett and Denzau (See Section IVD) which shows that in a city-school district of 150,000 students with 136 elementary and 40 secondary schools, a dedicated full time 40 channel educational cable distribution system can now be built for approximately the same order-of-magnitude cost per student as compared to only 4 channels by ITFS. With such a large scale channel capacity, multiple repetition of programs to meet the diverse scheduling needs of schools could be easily accomplished. In addition, the cable system has potential advantages for providing digital data services and other municipal and civic uses which ITFS could never hope to match.

While cable appears to be the solution for district center to school transmission in urban and suburban areas, economical linkage of district centers to national and regional production and storage libraries still remains a problem. At present some networking is being done by the Corporation for Public Broadcasting and some state wide systems using AT&T long lines to interconnect various stations. An alternative to this costly and preemptible system is the possible use of communications

satellites to distribute programming from a few central sources to district centers or even direct to individual schools in isolated areas. Several regional experiments to link schools in Alaska, the Rocky Mountain States, and Appalachia via satellite to video tape libraries have been proposed. However until recently little has been done to use the unique capabilities that a satellite system could offer to realistically cope with not only the technical problems of ITV transmission but also the multiple social, political and educational barriers which up to now have blocked ITV distribution on a national scale.

c. Teacher Utilization

Assuming that even if there was abundant programming available which could be rapidly and economically distributed there would still be resistance to the television medium because it challenges the traditional professional position of the classroom teacher. At present, there appears to be no consensus as to the best pedagogical or economical combination of television and teacher in the classroom. Schools in the near future may find it economically and technologically feasible to begin experimenting with various teacher/technology substitution trade-offs. There are many such combinations listed below in Table 6.

TABLE 6

TEACHER-TECHNOLOGY SUBSTITUTION TRADE-OFFS

	T = Teachers	P = Paraprofessionals	S = Students	C = Technology
#1	T		S	C+
#2	T		S	C+
#3	T		2S	C+
#4	T	P	3S+	C+
#5		P	S or 2S	C+

In Table 6, paraprofessionals are non-professional people that are interested in education, have empathy for children and who can be easily

trained to coordinate audio-visual media and/or computer-aided instruction in the classroom. Technology (C) is illustrated as a weighting factor where (+) is representative of the present situation in which various technologies (films, slides, tape recorders, etc.) are used in the classroom in a sporadic manner for enrichment purposes. A (C+) rating would be representative of the employment of a major technological investment such as a closed circuit ITV system or a series of computer-aided instruction terminals in the classroom.

Situation No. 1 is generally representative of the present level of technology utilization in the schools. The ratio is one teacher (T) to twenty-five students (S) plus the indifferent use of technology (C+). In this case any financial outlay for equipment is strictly an add-on cost to the educational process with little realistic return in improved educational quality. In No. 2 an additional increment in the technological area is made, the installation of a closed circuit ITV system on the school or district level. In this example programming is used in a truly coordinated effort to improve instruction in selected areas of study. Generally, the teacher stays in the classroom and watches the program with the student so that he may help to answer any questions about the lesson. Here again the cost of increased technological utilization is additive in nature but justifiable (if properly programmed and administered) by increased quality in instruction. Situation No. 3 is similar to No. 2, except that the teacher (T) handles twice as many students (2S) by working with one group while the other is watching the programs. Here the cost of the technical increment is substitutive because it frees the teacher to work with more students.

Situations No. 4 and No. 5 use various combinations of teachers, paraprofessionals, and technology to increase learning effectiveness. No. 4 combines a teacher (T) and a paraprofessional to help administer the media system (C+) with a substantial increase in students. Here there is an economic trade-off between the additive cost of (C+) + (P) and (T)'s ability to manage more students (3S+). Situation No. 5 may become applicable at more advanced levels of instruction where programmed ITV is used for individual instruction under the guidance of a paraprofessional who supervises the student's use of the media.

The multiple variables involved in the ITV process make it impossible to give any accurate estimate of the actual utilization level of ITV in the classroom either at the present time or in the future. There is a tremendous need for a substantial and unbiased research effort to determine the extent to and the manner in which the television medium and the individual programs themselves are actually implemented in the classroom. This in itself would help serve as a starting point to determine how best television can be used in classroom instruction.

d. Coordinated Advancement

In conclusion, it must be noted that increases in ITV utilization are not dependent on any single factor in the ITV process but the coordinated advancement of all three phases: production, distribution, and classroom utilization. While the trends toward national program sources and rapid electronic distribution point toward easy access of large amounts of quality programming, these advancements cannot be successfully implemented without a substantial change in education's traditional conception of the role of the classroom teacher. It is in the classroom that the battle for ITV, at least in the public schools, will be won or lost. It may develop that, due to increases in teacher militance and over supply of educational labor, ITV may find its most applicable format outside the formal school system as an alternative form of education in a de-schooled society.

II.D. COMPUTER-BASED INSTRUCTION

A memorandum has been prepared by J. P. Singh and R. P. Morgan to provide background information on Computer-Based Instruction (CBI); its status, cost-effectiveness and telecommunications requirements.^[5]

Particular attention is given to the role of telecommunications and, in particular, communications satellites in large-scale, totally and partially centralized CBI systems and in extending CBI services to rural, small and less-affluent communities and schools.

In slightly over twelve years since its inception, CBI has shown promise of being more cost-effective than traditional instruction for

certain educational applications. Pilot experiments are underway to evaluate various CBI systems. Should these tests prove successful, a major problem confronting advocates of large-scale CBI utilization is the conflict between the organization of the traditional school system and optimal methods of utilizing computer-based instruction. The memorandum discusses the larger issues involved and presents a summary of experiments and costs of a variety of CBI experiments and approaches.

According to an NEA survey conducted in the spring of 1970, 7.7% of all elementary and secondary school teachers who were questioned indicated that their school systems were using CAI, with more use in the Northeast and Middle States than in the Southeast and West, and more use in urban and suburban areas than in rural ones (See Figure 11). In general, CAI is still in the research and development phase with primary use clustered around research centers. The costs of most CAI systems in use today is quite high, falling in the range of from \$2.60 to \$15 per student hour as compared with traditionally administered (teacher) instruction (TAI) costs of roughly \$0.60 per student hour for elementary and secondary education and \$1.50 per student hour for higher education. Further CAI cost reductions are clearly required if it is to be cost-competitive with TAI. A review of systems costs and trends indicated that such reductions should in fact be possible. For example, the PLATO IV system is to achieve a cost of roughly \$0.34 per student contact-hour through the use of large, time-shared computers and plasma display panels. However, this cost does not include the cost of writing and debugging appropriate software. Furthermore, at one extreme, the largest savings would appear to stem from substitution of computer for the teacher, a step which is clearly a major political development and one which, if taken, could have far reaching implications, many of which can not now be foreseen. The cost and benefits to be derived from various ways of utilizing CAI both within and without lock-step school systems requires careful additional study.

There are three different ways in which CAI systems are being developed and implemented (See Figure 12). In the first, a highly decentralized approach, a low-cost computer serves a small number of student terminals at a single location. At the other extreme, a highly centralized system with a single high-capacity computer serves a large number of terminals

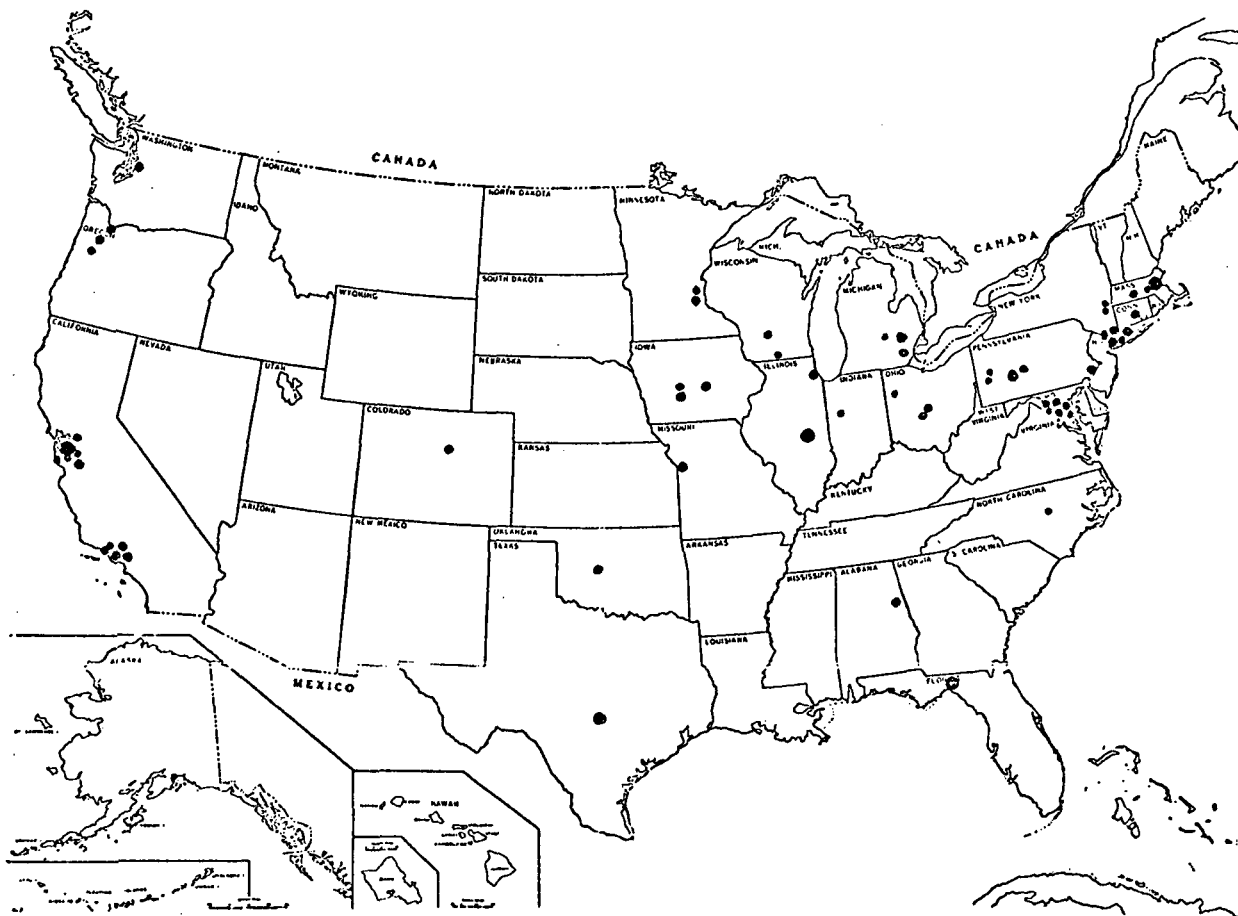
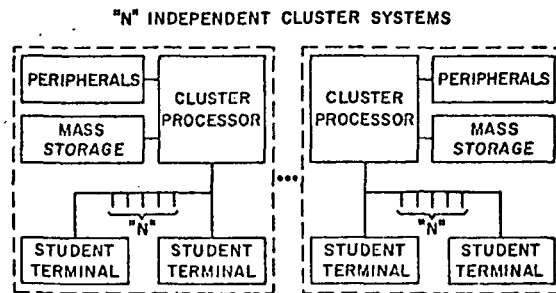
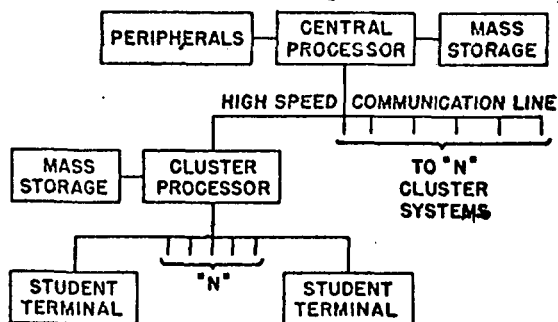


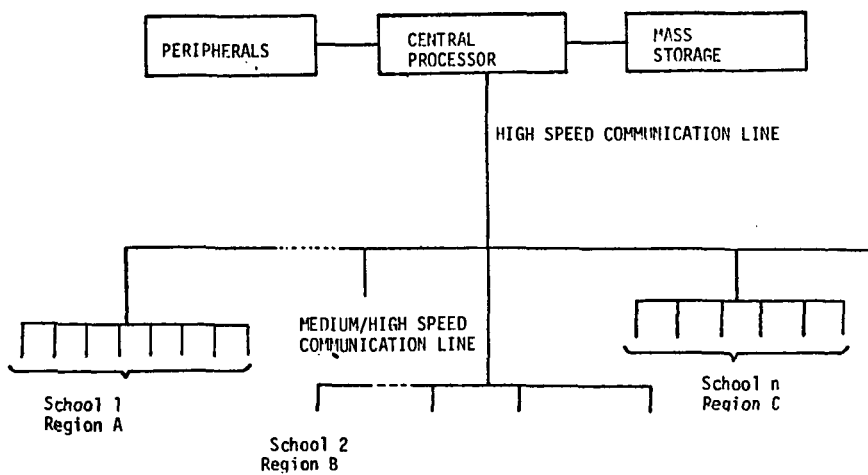
Figure 11. Location and Distribution of Major CAI centers



[A] Decentralized CAI System



[B] Combined Central-Cluster Operation



[C] A HIGHLY CENTRALIZED CAI SYSTEM

Figure 12

over a wide geographical region. In between these extremes is a system in which several terminals in every school form a sort of cluster and each cluster has its own limited mass storage and processors. These clusters are tied to and share the hardware and software capabilities of a common single processor. Examples of these approaches include the decentralized CAI system of Computer Curriculum Corporation, Palo Alto, California, the centralized PLATO IV System and the intermediate CAI system operated by the Philadelphia Schools.

Extending CAI/CMI services to isolated, not-so-affluent and small rural schools is a very difficult but potentially rewarding task. Large urban schools and/or school systems can either have a completely centralized CAI system like PLATO IV, TICCET, etc., or if a school system population is very large and beyond the capability of a single CAI system, a partially decentralized system based on central and cluster processing to minimize the system cost by cutting down redundant mass storage requirements. Affluent suburban schools will probably go for a completely self-contained unit such as the one being produced in Palo Alto. For rural schools, ways will have to be devised in which hardware costs could be shared by a larger population so that CAI costs for rural areas are comparable to those in urban and suburban schools with larger student density.

Large-scale and intensive utilization is the key to low per-pupil costs. Some means of low-cost telecommunications must be found if rural communities and sparsely populated regions are to benefit. An analysis, based upon work performed by Jamison, indicates that communications satellites seem to hold distinct advantages over existing commercial telephone communications for linking remote terminal clusters with a central computer where computer-cluster separation is 150-200 miles or greater. A specially designed high power satellite capable of delivering signals to low-cost, small-diameter antenna headends could provide a variety of services for educational users in addition to CBI, such as remote batch processing of administrative and educational data, public and instructional television, remote electronic browsing, etc. More detail systems analysis and cost-benefit studies are required. No insurmountable technical problems are foreseen.

II.E. EDUCATIONAL COMPUTER UTILIZATION AND COMPUTER COMMUNICATIONS

This memorandum^[6] by J. P. Singh and R. P. Morgan consists of three major parts. First, the role of computers in education is examined and both current status and future requirements are analyzed. Then, an analysis is presented of the telecommunications aspects of computer communications which includes discussion of hardware aspects, systems design aspects and existing physical plant facilities. Finally, the use of communications satellites is examined for providing telecommunications for computer applications, with emphasis on high powered satellite systems involving small, interactive earth terminals.

Computers are currently being used in education for a variety of purposes, e.g. instruction, research, administration, information retrieval and career guidance at a variety of levels; elementary, secondary, higher and vocational education (See Figure 13). Overall computer utilization has grown rapidly in the U.S. within the last ten years. At the elementary and secondary school level, the primary use appears to be for administration whereas for higher education, utilization is divided roughly equally among research, instruction and administration.

According to a recently conducted Survey of Computing Activities in Secondary Schools, some 34.4% of the secondary schools reported some kind of computing activity. Of the schools responding to the survey, 30.5% were using computers for administrative purposes and only 12.9% reported instructional usage. It was not surprising to find that geographic dispersion of these user schools showed clustering around major metropolitan areas. Even in these cities, instructional users were not satisfied with the presently available access to the computer.

Computers in higher education are altogether a different matter. Extensive use by colleges and universities began in the early 1960's and has grown rapidly. Computer usage in higher education (1966-67 data) was as follows:

- Research - 40%, about \$95 million
- Instruction - 30%, about \$69 million
- Administration - 28%, about \$65 million
- Other - 2%, \$5.8 million

	Instructional Applications of Computers					Administrative Applications of Computers				Research Applications of Computers							Library Applications			
	Instruction about Computers			Instruction with Computers						Research on Computers			Research with Computers							
	Specialist Instruction	Service Instruction	Survey Instruction	Computer Assisted Instruction/ Computer Based Instruction/ Computer Managed Instruction	Computer Assisted Problem Solving	Computerized Financial Operations	Computerized Personnel Management	Computerized Program Management	Computerized Facility Management	Hardware Oriented Research	Software Oriented Research	Research on Theory and Science of Computing	Number Processing	Symbol Processing	Data Processing	Event Processing	Picture and Sound Processing	Circulation Automation and Computer Aided Cataloging		Computerized Indexing and Retrieval	Computer Aided Vocational Guidance
Elementary Schools				X		X	X	X	X						X					
Secondary Schools			X	X	X	X	X	X	X						X					X
School District						X	X	X	X						X			X		
Vocational Schools	X		X	X		X	X	X	X						X					
Community Colleges	X	X	X	X	X	X	X	X	X						X					X
Colleges	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	
Universities	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

Figure 13. Computer Applications in Education

Larger schools and those granting higher degrees have greater access to computing facilities than smaller schools and those that do not grant higher degrees. In 1967, the President's Science Advisory Committee (PSAC) recommended some 20 minutes of computer time per student per year as a goal for computer usage in higher education. However, according to a recent Rand report, about half of the nation's colleges and universities are entirely without computer services as the 1970's begin.

There are a number of alternatives for providing computer services to educational institutions (See Figure 14). Remote time-sharing and remote batch processing, two modes of computer access, offer some advantages for small and remotely located institutions. These include less expense and less long-term commitment than owning an equivalent on-campus facility, less management and administrative supervision and better quality and variety of services than a small institution could manage on a dedicated basis. Trade-offs between remote time sharing and remote batch processing are explored as are trade-offs between minicomputers and resource sharing.

Educational computing systems which involve use of telecommunications may be classified as either centralized or distributed computing networks. In the centralized network, actual computing and maintenance for all users are carried out at a central location whereas in a distributed network, computing can be carried out at more than one location. Both types of networks can be implemented on either an inter- or intra-institutional basis. The memorandum explores various aspects of computer communications of importance in resource sharing, i.e. the sharing of computer power between "have" and "have not" institutions, including multi-access computer communications, remote batch processing and inter-computer communications. The latter category involves two way communication at machine-to-machine speeds.

An examination of existing telecommunications plant and costs reveals that unless communications costs are significantly lowered, they could become the most expensive part of large-scale computing networks and long-distance information transfer. The cost of a telephone line appears to have been roughly constant over the past decade whereas the cost of computers has been dropping at about 25% per year. This may seem surprising in view of advances in such technologies as cable, millimeter

FIGURE 14

MATRIX OF COMPUTER ACCESS AND SOURCE OPTIONS

Source of Service	Mode of Access				
	Dedicated	Batch Processing	Remote Batch Processing	Multi-Programming	Time-Sharing
Centralized On-Campus Facility	X	X	X	X	X
Distributed Computers On-Campus	X	X		X	
Commercial Service Off-Campus		X	X		X
Shared Cooperative Facility Off-Campus		X	X		X

waveguides, microwave, etc. However, the problem is that over 80% of the telecommunications cost is in the local telephone plant and associated switching equipment. New, specialized common carriers such as DATRAN and MCI offer possibilities for economies in this area.

Communications satellites offer certain advantages for interactive multi-access computing and remote batch processing provided that the local telephone switching plant can be bypassed. Small earth terminals colocated at the computing facilities and shared with other services such as ITV can be designed to avoid the high error rates associated with existing switching equipment. Essential cost-benefit analyses remain to be performed.

Because of the long communications circuit length associated with synchronous satellite systems, at least 0.5 seconds of propagation time is an inherent delay in such systems. Various technical communications schemes are proposed to minimize the effects of this delay. If the system is such that the user must wait for 1.0 second until his keyed in response appears on a display terminal, as would be the case in a Plato-type system, the delay involved is clearly intolerable. However, systems in which such character "echoing" is not intrinsic would appear to be perfectly feasible.

Recent filings by companies before the Federal Communications Commission for commercial domestic satellite systems were required discussed terms and conditions under which satellite services would be made available for data and computer usage in meeting educational requirements. Of eight applications that were filed, only four responded by spelling out their public service offerings and only one (MCI-Lockheed) explored possible computer usage. Only one proposal (Fairchild-Hiller) contemplates use of frequencies (2.5 GHz) and satellites power levels suitable for use of low-cost earth terminals for interactive communications.

We conclude that what is needed to satisfy computing requirements is relatively high-power (55-60 dBW e.i.r.p.) dedicated educational satellites capable of operation with a large number of small earth terminals. However, such a development would require a pooling of a large percentage of educational telecommunications users. Such cooperation presents major political-administrative-organizational problems. Technical problems appear to be solvable. The economics of satellite-based computer communications with small, display-terminal based interactive interconnections

appear to be attractive compared to terrestrial-based communications for distances greater than 70 miles. Preliminary communications systems design considerations are presented in Section IV of this Report.

II.F. UTILIZATION OF TELECOMMUNICATIONS BY UNIVERSITY, COLLEGE AND SCHOOL LIBRARIES IN THE UNITED STATES

1. Introduction

A study has been initiated by C. Niehaus of utilization of telecommunications by university, college and school libraries in the United States. An interim report from this study is presented verbatim below.

Libraries are divided into types, determined by the nature of their users. A common classification defines public, special, academic, and school libraries. Public libraries are self explanatory. Special libraries are those established by corporations, government bodies, professional societies, etc. Their collections usually cover a quite narrow range of topics extremely thoroughly. Access is often limited to members of the organization maintaining the library. Academic libraries include those of universities, colleges, and junior colleges. Libraries in elementary and secondary schools comprise the class of school libraries. They are not considered to be academic libraries because their needs and the collections they build are fairly distinct.

The scope of this report is limited to academic and school libraries. This limitation should be kept in mind when data are presented, since a substantial share of all library telecommunication is employed by public and special libraries. Furthermore, the nearly total lack of references in the literature to telecommunications in school libraries suggests that the extent of their utilization is negligible. Hence the information presented is essentially restricted to academic libraries. In the future, the interaction between academic, public and special libraries will be examined.

The type of communications considered is also restricted to the extent that systems which are only incidentally related to libraries are ignored. A particular effort has been made to avoid areas which have been extensively discussed elsewhere (e.g., ETV which might use library facilities, library-related CAI, etc.).

As a final preliminary remark, it should be emphasized that there is a general lack of statistics on the entire subject of library communication usage. Reports and descriptions of individual systems abound, but no national census of libraries has ever been compiled.

2. Budgets for Libraries

Current expenditures by local educational agencies for free public elementary and secondary education are tabulated annually by the Office of Education. However, the data collected do not reveal the share of resources allocated to libraries. At the present time, no national accounting of expenditures for school libraries exists.

Until such data become available, the most complete report is that of the Elementary and Secondary Education Act of 1965, Title II, which provides direct federal assistance for the acquisition of school library resources, textbooks, and other instructional materials. The third annual report, for fiscal year 1968, indicates that for 45.3 million public and private school pupils (92% of those eligible) a total of \$171.4 million was spent for school library resources, of which \$82.2 million was provided by ESEA Title II.^[8] It should be noted that these figures represent only a portion of the total expenditures for school libraries, since: 1) they do not include salaries, capital investment, etc; and 2) they do not include all schools in the United States.

Academic library operating expenditures are compiled by the National Center for Educational Statistics (See Table 7). Total expenditures for the aggregate United States have risen from \$183.7 million in 1961-62 to an estimated \$600 million for 1970-71. Expenditures per student have climbed from \$47.13 in 1961-62 to an estimated \$73.17 for 1970-71. However, expenditures as a percentage of total education and general expenditures have risen only slightly from 3.1% a decade ago to 3.8% at the present.

Federal funds have been perhaps the single greatest stimulant to the utilization of telecommunication by libraries. In addition to ESEA Title II mentioned above, ESEA (Title III) and the Higher Education Act (Title II-A--Special Purpose Grants) encourage the use of communication by offering grants for innovative cooperative programs and to establish and strengthen joint-use facilities. Not all of the libraries supported

Table 7

SUMMARY OF COLLEGE AND UNIVERSITY LIBRARY STATISTICS FOR ACADEMIC YEARS 1961 - 1970
AGGREGATE UNITED STATES*

<u>Item</u>	<u>1961-62</u>	<u>1962-63</u>	<u>1963-64</u>	<u>1964-65</u>	<u>1965-66[†]</u>	<u>1966-67[†]</u>	<u>1967-68[†]</u>	<u>1968-69</u>	<u>1969-70[†]</u>	<u>1970-71[†]</u>
Total Expenditures in millions (excludes capital outlay)	\$183.7	\$213	\$246	\$276	\$320	\$366	\$416	\$510	\$550	\$600
Number of libraries	1985	2075	2140	2175	2207	2252	2300	2370	2500	2600
Number of students (millions)	3.9	4.3	4.8	5.3	5.9	6.4	7.0	7.3	7.6	8.2
Expenditures per student	\$47.13	\$50.95	\$51.25	\$52.75	\$54.23	\$57.03	\$59.29	\$69.86	\$72.36	\$73.17
Expenditures as a percentage of total education and general expenditures	3.1	3.2	3.3	3.3	3.3	3.6	3.7	3.7	3.8	3.8

*Adapted from "College and University Library Statistics", Theodore Samore in the 1971 Bowker Annual Review of Library and Book Trade Information, Carole Collins, Ed., pp. 8-10, R. R. Bowker Company, New York, 1971.

[†]Estimated.

by this legislation will employ telecommunication, but the potential to do so is great. Title IX (Networks for Knowledge) was added to the Higher Education Act of 1968 with provisions for support of cooperative exploration of new computer and communication technologies among institutions of higher learning. However this program has never been funded.

Title III (Interlibrary Cooperation) of the Library Services and Construction Act (LSCA) of 1966 has aided in the creation of 35 telecommunications networks connecting 800 libraries. No data on how many of these libraries are academic are available. LSCA is scheduled to continue until at least 1975.

3. Types of Communications Utilized

Teleprinters, commonly referred to as teletypes, are by far the most common means of telecommunication used by libraries. They are particularly suited for library use.

There are many examples of teletype systems between libraries. A few of the more prominent are the Ohio College Library Center, the New England Library Information Network (NELINET), the Washington State University system, the University of California system, the Texas State University library network, the Oklahoma Teletypewriter Interlibrary System (OTIS), the New York State Interlibrary Loan Network (NYSILL), and the State University of New York (SUNY) Biomedical Communication Network. Almost all such networks include public and special libraries as well as academic members.

Teletype service is supported by either switched networks or leased lines. Systems using leased lines are known to exist but the extent of their use nationally is not released by the common carriers. The teletype switched network (TWX) is operated by Western Union, and a national directory of subscribers (similar to a telephone book) is published. The 1971 TWX directory lists 225 academic library subscribers out of a total of 499 library subscribers of all types. Since there were approximately 2600 academic libraries in the United States for the 1970-71 academic year, about 8.6% were TWX subscribers. This is a slight increase from 6.5% in 1968 when 154 out of 2370 academic libraries were subscribers.

After teletype service, telephone systems are the most commonly utilized communication technique. Wide Area Telephone System (WATS) service is known to be in use in a number of areas, often organized around a state library (a special library) as a bibliographic and switching center. North Carolina, Washington State, and Michigan are prominent examples of academic library networks. However, since no data on subscribers are available from the common carriers, a survey would be required to establish national utilization.

Teletype and telephone are the only systems in general use. Telefacsimile has received a large amount of publicity, but is currently in use only in the Pennsylvania State University library system and the Bay Area Reference Center in San Francisco (public libraries only). There have been numerous short lived trials and pilot systems using telefax, but all except the above two exceptions have failed for one or more of the following reasons: high cost, poor quality copy, unacceptably long transmission time, low volume demand for fast service, terminal equipment which cannot copy from bound volumes. The cost factor is probably the most significant obstacle to increased utilization. At a cost of at least \$1.00 per page under the most favorable circumstances it is understandable that demand is low. Technology advances or lower communication rates, or both, will be required before telefacsimile is widely utilized by libraries.

Broadcast television is far too expensive for libraries to even consider as a means of communication. Community antenna television (CATV) has been utilized by the Natrona County (Wyoming) Public Library to provide a video reference service. Viewers phoned in questions and then watched the reference staff find and relay the answers on camera. No academic library use of CATV has been reported in the literature, but they (like all libraries) are looking to the FCC for help. If cable operators are required to provide the possibility for two-way communications, libraries could use CATV for facsimile reproduction, information retrieval, and other purposes.

4. Predictions for the Near Future

In a paper presented at the Conference on Interlibrary Communications and Information Networks in October, 1970, John Bystrom summarized the prospects for future utilization:

"There is as yet no library strategy for the development and use of statewide telecommunication systems and urban cable systems or for international exchange by satellite. The use to which libraries will put these telecommunication systems is a matter of conjecture."

High costs, organizational obstacles, fear of loss of local autonomy, lack of standardization, and other problems will continue to impede the formation of library consortia utilizing telecommunications. However, developments in the communications industry will almost certainly spur growth in many areas. The anticipated uses of CATV have already been mentioned. Increased utilization of both teletype and telephone for regional consortia can reasonably be expected. Communications satellites have been suggested as an integral part of widely dispersed networks. The Lister Hill Center at the National Library of Medicine (NLM) recently demonstrated (April 1970) the utility of satellite communications with a conference call by means of NASA's Applications Technology Satellite I linking NLM, the University of Alaska, the University of Wisconsin, and Stanford University. The University of Hawaii has proposed to NASA an international consortium of Pacific Basin universities and other educational organizations linked by satellite. The network would permit exchange of resources, the transmission of reference inquiries by voice, and the possible use of facsimile.

All such projects are experimental and do not reflect any permanency of use. Detailed plans of library telecommunications systems under development are virtually nonexistent. The performance analyses of the pioneering systems are just now beginning to be reported and evaluated. It is likely that no accurate estimates of library telecommunication utilization during the next few years will be possible until these initial evaluations have been fully assessed.

II.G. PUBLIC EDUCATION FINANCES: 1949 - 1985

To complement the discrete data-base studies summarized previously, it was deemed important to make some broader-gauged studies which examine economic, educational and legal aspects. An investigation was undertaken by Denzau which had as its main objective the development of estimates of budgets which might be available for media-technology in education for the next five to fifteen years. Some initial results of what will very likely prove to be a continuing study have been developed in a memorandum.^[7] These results are summarized below.

Tables 8 and 9 present information on public educational expenditures in the United States. In 1949, the U.S. spent around \$9 billion dollars for all of education, representing 3-1/2% of the Gross National Product (GNP). By 1967, these figures had grown to \$57.5 billion dollars and more than 7% of GNP, respectively. This rapid growth seems very much tied to growth in both income and school enrollment.

Proceeding in a predictive and descriptive way, Denzau has related expenditures to income per capita and enrollment through a log-linear model. Data from previous years is used to derive the equation:

$$D_t = 0.337 Y_t^{0.99845} (0.7 E_t + S_t)^{1.5533}$$

where, D_t = current expenditures (billions of 1958 dollars),

Y_t = real personal income per capita (thousands of 1958 dollars),

E_t = K-8 enrollment (millions),

S_t = 9-12 enrollment (millions).

Income and enrollment elasticities of approximately 1.0 and 1.5 are therefore derived. This equation is then used as a predictor for the years 1975, 1979 and 1985. (See Tables 10 and 11.) Parametric curves are required because of enrollment projections which are in turn based upon various population projections.

Figures 15, 16 and 17 have been developed to give some indication of money which might be available for media-technology, based upon the above projections, as a function of the pupil-teacher ratio. It can be seen that for 1975 the results of the various projections all fall within a narrow range of values and that from 3 to 6 billion dollars might be expected to

Table 8

Expenditures for education, including capital outlay,
by level of instruction and by type of control:
United States, 1967-68
(in thousands of dollars)

Expenditures, by level of instruction	Total	Publicly controlled	Privately controlled
1	2	3	4
All levels (elementary, secondary, higher) ¹	\$57,477,243	\$45,454,599	\$12,022,644
Current expenditures (including interest)	49,161,350	38,903,821	10,257,529
Capital outlay or plant expansion	8,315,893	6,550,778	1,765,115
Elementary and secondary schools ²	37,271,608	32,983,724	³ 4,287,884
Current expenditures (including interest)	32,462,564	28,727,933	³ 3,734,631
Capital outlay	4,809,044	⁴ 4,255,791	³ 553,253
Kindergarten through grade 8 ⁵	23,578,691	20,866,098	2,712,593
Grades 9-12 and postgraduate ⁵	13,692,917	12,117,626	1,575,291
Other elementary and secondary schools ¹	300,000	200,000	100,000
Higher education (excluding subcollegiate departments) ⁶	19,905,635	12,270,875	7,634,760
Current expenditures	16,398,786	9,975,888	6,422,898
Educational and general	13,108,420	8,137,659	4,970,761
Auxiliary enterprises	2,577,941	1,511,314	1,066,627
Student-aid expenditures	712,425	326,915	385,510
Expenditures from plant funds ⁷ ..	3,506,849	2,294,987	1,211,862

¹Includes an estimate for "other" elementary and secondary schools such as residential schools for exceptional children, Federal schools for Indians, federally operated elementary and secondary schools on posts, and subcollegiate departments of institutions of higher education.

²Excludes expenditures for the "other" schools described in footnote 1.

³Estimated on the basis of expenditure per teacher in public elementary and secondary schools.

⁴Includes capital outlay of \$169,146,168 by State and local schoolhousing authorities.

⁵Distribution between grade-groups (kindergarten-grade 8, grades 9-12 and post-graduate) estimated on the assumption that the cost per pupil in grades 9-12 is 50 percent higher than in grades K-8.

⁶Excludes schools of nursing not affiliated with colleges and universities.

⁷Excludes an estimated \$668 million expended for plant expansion directly from current funds (\$437 million by publicly controlled and \$231 million by privately controlled institutions of higher education).

Source: U.S. Department of Health, Education and Welfare.
 "Digest of Educational Statistics, 1970 Edition",
 Table 24.

Table 9

Gross National product related to total expenditures¹ for education:
United States, 1929-30 to 1969-70

Calendar year	Gross national product (in millions)	School year	Expenditures for education	
			Total (in thousands)	As a percent of gross national product
1	2	3	4	5
1929	\$103,095	1929-30	\$3,233,601	3.1
1931	75,820	1931-32	2,966,464	3.9
1933	55,601	1933-34	2,294,896	4.1
1935	72,247	1935-36	2,649,914	3.7
1937	90,446	1937-38	3,014,074	3.3
1939	90,494	1939-40	3,199,593	3.5
1941	124,540	1941-42	3,203,548	2.6
1943	191,592	1943-44	3,522,007	1.8
1945	212,010	1945-46	4,167,597	2.0
1947	231,323	1947-48	6,574,379	2.8
1949	256,484	1949-50	8,795,635	3.4
1951	328,404	1951-52	11,312,446	3.4
1953	364,593	1953-54	13,949,876	3.8
1955	397,960	1955-56	16,811,651	4.2
1957	441,134	1957-58	21,119,565	4.8
1959	483,650	1959-60	24,722,464	5.1
1961	520,109	1961-62	29,366,305	5.6
1963	590,503	1963-64	36,010,210	6.1
1965	684,884	1965-66	45,397,713	6.6
1967	793,544	1967-68	57,477,243	7.2
1969	932,100	1969-70	² 69,500,000	7.5

¹ Includes expenditures of public and nonpublic schools at all levels of education (elementary, secondary, and higher education).

² Estimated.

Source: U.S. Department of Health, Education and Welfare, "Digest of Educational Statistics, 1970 Edition", Table 25.

Table 10

PREDICTIONS OF PUBLIC ELEMENTARY AND SECONDARY
SCHOOL OPERATING REVENUES

	1969*	1975	1979	1985
1) <u>BASIC PROJECTION</u>				
Total Revenue (In Billions of Dollars)	33.107	38.215	41.348	50.107
Revenue per Student (In Dollars)	710.27	851.71	965.51	1125.76
2) <u>USOE PROJECTION**</u>				
Total Revenue (In Billions of Dollars)	- - -	38.1	41.6	- - -
Revenue per Student (In Dollars)	- - -	831.88	912.28	- - -
3) <u>ENROLLMENT†</u>				
(In Millions of Students)	46.610	44.569	42.825	44.510
Based on D-1 Census Bureau Population Projections				

*Actual data from "Digest of Educational Statistics, 1970 Edition", U.S. Department of Health, Education and Welfare.

**Based upon enrollment projections from U.S. Office of Education, "Projections of Educational Statistics to 1979-1980", Report OE-10030-70, Washington, D. C., 1971.

†Taken from "Current Population Reports", Series P-25, No. 365.

TABLE 11
BASIC EXPENDITURE PROJECTION, D-1, AND TEACHER COMPENSATION
 (constant 1969-1970 dollars)

	1967	1975	1979	1985
1) Basic projection of operating expenditures (in billions)	26.877	38.215	41.348	50.107
2) Teacher compensation* (in billions)	15.582	22.126	23.940	29.012
3) Number of Teachers** (in millions)	1.8552	2.079	2.089	2.2
4) Pupil-Teacher Ratio	23.6	21.4	20.5	20.2
5) Mean Teacher Compensation (in thousands)	8.399	10.643	11.460	13.187

*Predictions based on 1967 ratio of Teacher Compensation to Expenditures (0.579).

**All years except 1985 taken from U.S. Department of Health, Education and Welfare Projections.

FIGURE 15
BUDGET CONSTRAINT FOR MEDIA-TECHNOLOGY
(IN BILLIONS OF 1969-70 DOLLARS)
VERSUS PUPIL-TEACHER RATIO FOR VARIOUS POPULATION PROJECTIONS
1975

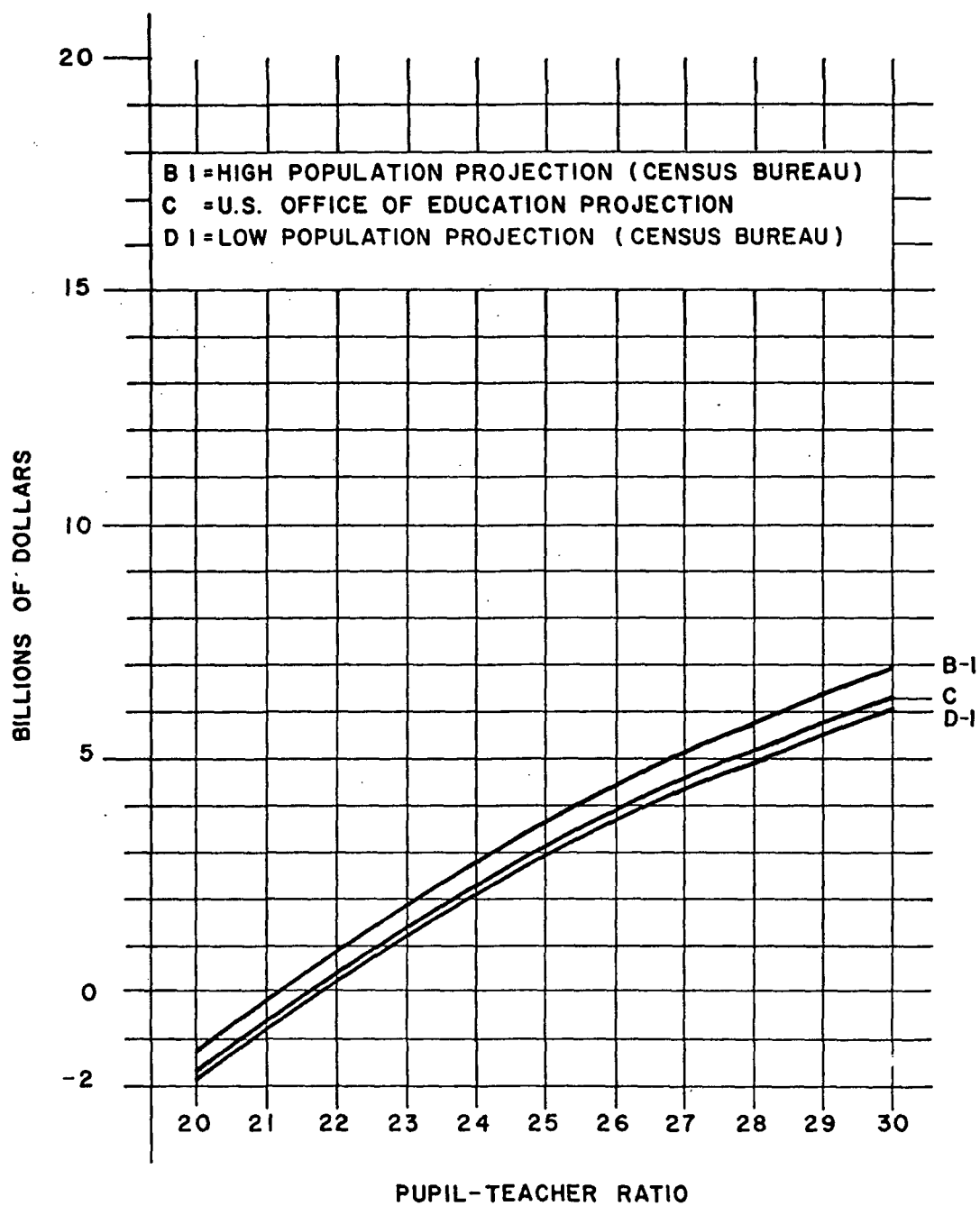


FIGURE 16
BUDGET CONSTRAINT FOR MEDIA TECHNOLOGY
(IN BILLIONS OF 1969-70 DOLLARS)
VERSUS PUPIL TEACHER RATIO FOR VARIOUS POPULATION PROJECTIONS
1979

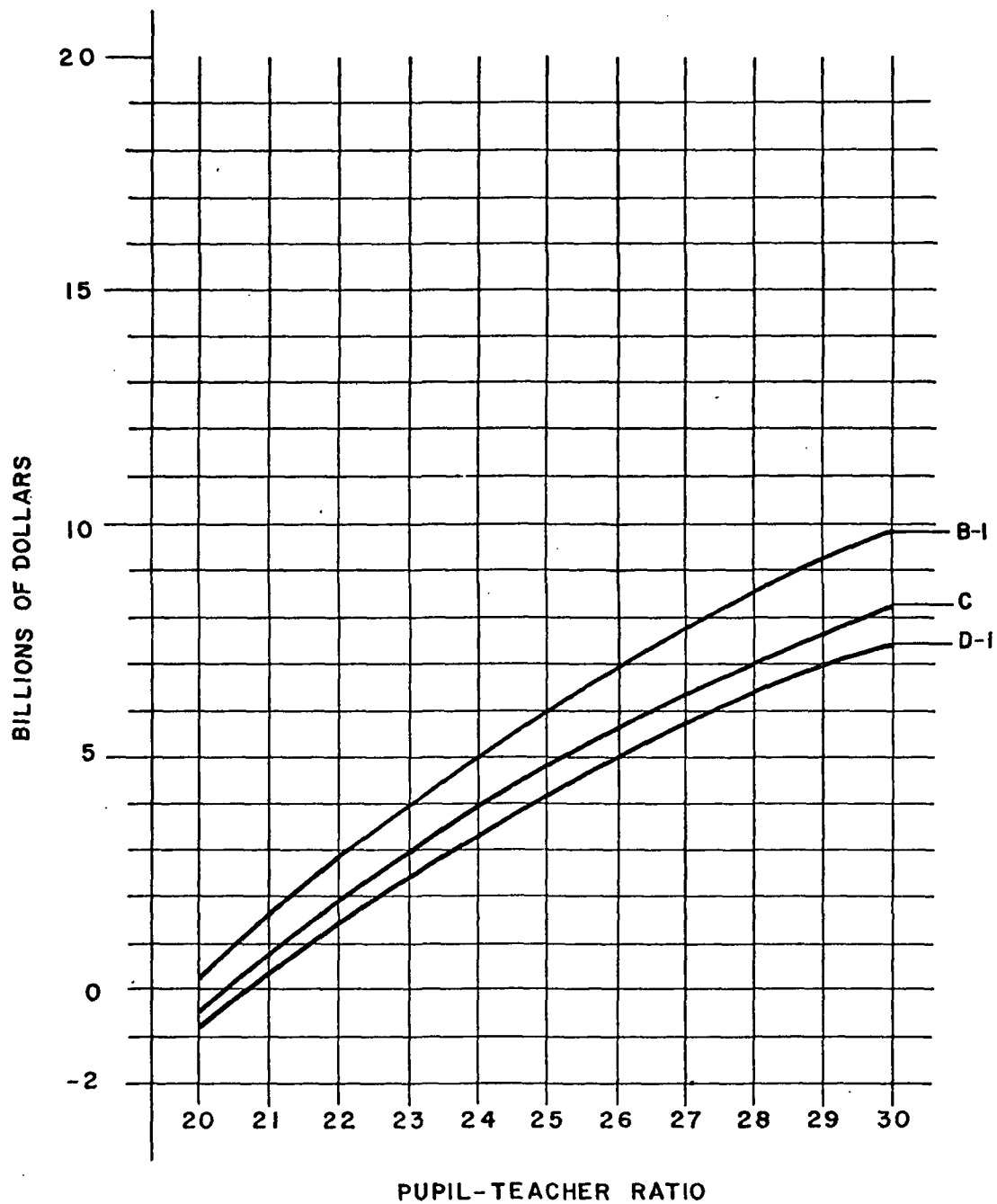
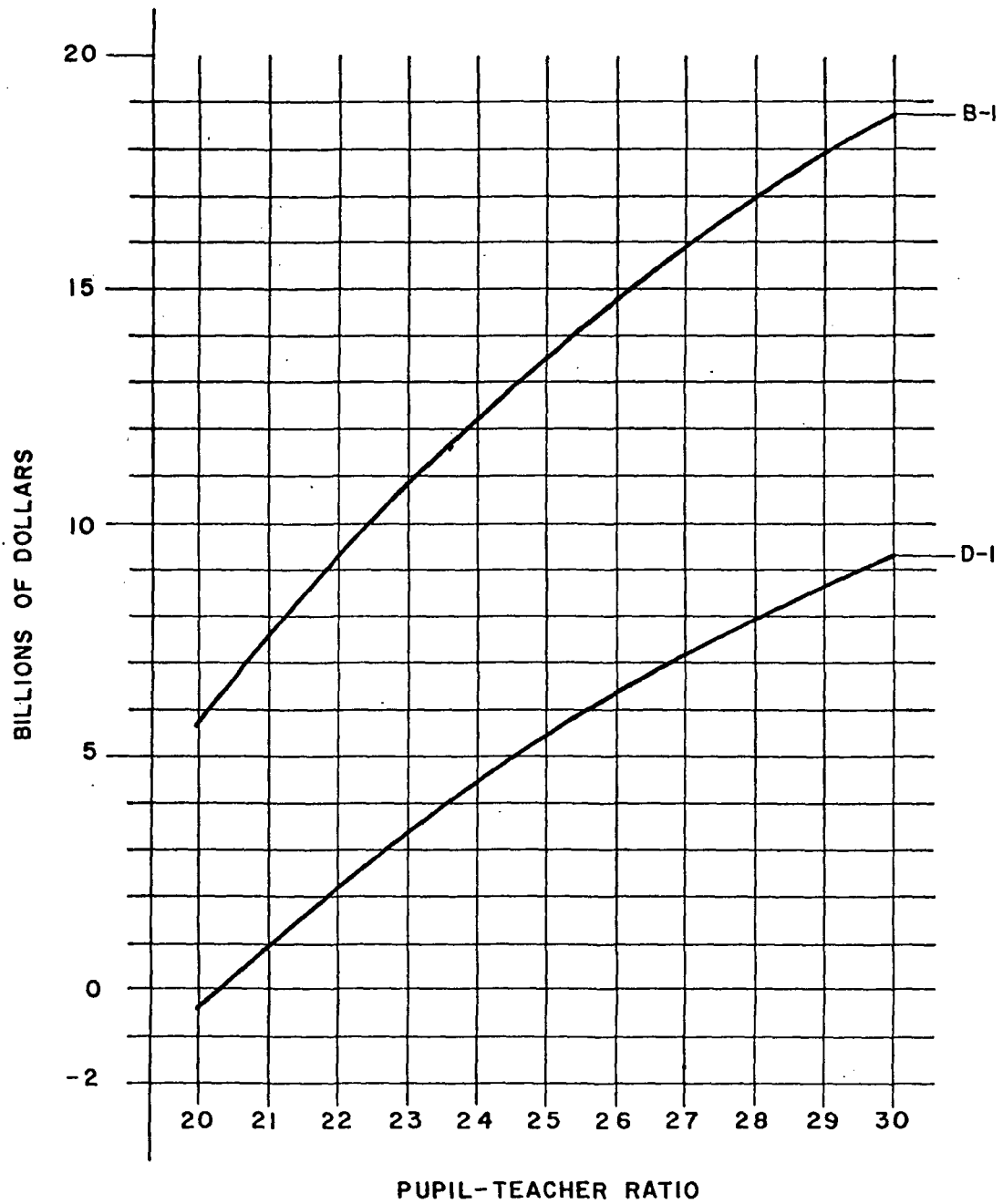


FIGURE 17
BUDGET CONSTRAINT FOR MEDIA TECHNOLOGY
(IN BILLIONS OF 1969-70 DOLLARS)
VERSUS PUPIL-TEACHER RATIO FOR VARIOUS POPULATION PROJECTIONS
1985



be available for pupil-teacher ratios of 25 and 30 respectively. For 1985, there is considerably more spread in the various projections and results are less reliable.

The Denzau study would seem to indicate that there might well be sizable funds available for media-technology in the time frame under consideration. However, as Denzau has pointed out, the study is an initial attempt. Further work is required to examine the 1.5 enrollment elasticity factor and differences between this work and Office of Education expenditure predictions. A cross-sectional study approach is planned. It should also be kept in mind that the study assumes no major disruption in prior funding patterns. As this study was being carried out, court rulings in California and Minnesota have thrown into question the use of the property tax as the primary base for educational support. Hence, the risky business of prediction becomes even more risky. The whole area of public education financing remains a fruitful one for future research.

The Denzau study summarizes a great deal of useful information on educational expenditures. Although decisions concerning future media-technology funding are political as well as economic in nature, this attempt to analyze public educational finances provides useful information for our overall study.

II.H. LEGAL RESTRAINTS ON DISSEMINATION OF INSTRUCTIONAL MATERIALS BY EDUCATIONAL COMMUNICATIONS SYSTEMS

A monograph is being prepared by N. Bernstein to determine the legal restraints on the dissemination of instructional materials by educational communications systems.^[8] The purpose of the monograph is to identify and evaluate those legal doctrines that will impose constraints on the efficient development and utilization of such systems. Research on state public educational requirements was summarized in a previous progress report.^[2] The second portion of the study has dealt with the legal effects of the Copyright Act of 1909. The tentative conclusions of that analysis, as outlined by Professor Bernstein, are as follows:

"The copyright statutes in the United States have been enacted pursuant to the constitutional directive to Congress to "promote the progress of science and the useful arts, by securing for limited times to authors and

and inventors the exclusive right to their respective writings and discoveries." The effort has been to provide adequate protection for the author's legitimate economic and moral interests in his literary or artistic expressions, without unduly hampering the public's interest in the broadest possible dissemination of ideas and intellectual development.

The current copyright statute is the Copyright Act of 1909. This Act operates by affording a wide variety of exclusive rights to the authors of published "writings." These rights include the right to copy; translate; dramatize; arrange; deliver nondramatic literary works in public for profit; perform dramatic work publicly; and to perform musical compositions publicly for profit. The Act lists 13 separate classes of copyrightable works, ranging from books to motion-picture photoplays.

The use of copyrighted works in the classrooms will create conflicts with the statute primarily when the teacher desires to reproduce all or a part of the work, in apparent conflict with the copyright owner's exclusive right to "copy." The courts have evolved the doctrines of "fair use" to permit such reproduction under certain circumstances without liability. This doctrine permits such copying wherever the taking is not substantial and is justified by a purpose other than commercial exploitation. The doctrine does not appear to provide a satisfactory solution to the problems of classroom copying, both because of its inherent vagueness and its failure to recognize the opportunities for educational improvement afforded by new reproduction technology such as reprography.

An educational communication system can infringe upon the exclusive rights of a copyright owner in several ways. The recreation of the work in a form suitable for transmission over a network can be a violation. The same is true with respect to the transmission itself. If, upon receipt, the material is stored in a computer retrieval system, that storage may be an infringement. Finally, every time the material is brought out of the computer in whole or in part, in hard copy or screen display, the rights granted exclusively to the copyright owner may be involved.

Efforts have been underway to revise the Copyright Act of 1909 for some time. The Register of Copyrights was authorized to undertake revision studies in 1955. He submitted his studies, plus a draft bill, in 1961. Revision bills have been introduced in Congress regularly since 1964, but

none has passed. A revision bill is currently pending in the Senate, but has little chance of passing.

The pending revision makes several efforts to deal with classroom copying problems. The "fair use" doctrine is explicitly recognized as a permissible act, exempting reproduction for purposes such as teaching and research. In addition, performance or display in the course of "face-to-face teaching activities" are exempted from the proposed Act.

The pending revision does little to resolve the copyright uncertainties with respect to educational communication systems. By expanding the definition of "copying," the revision appears to vest exclusive right to prepare material for transmission, computer input and all output in the copyright owner. Performance or display of nondramatic literary works is permissible as a part of the transmission of materials used to assist instructional activities. The only other available exemption is that afforded by the new "fair use" section.

The proposed copyright revision does not meet the realistic needs of educational communications system. Copyright owners should be given a first opportunity to fulfill the needs of educational institution for suitable copies at reasonable prices; however, if they fail to meet such needs, the institutions should be free to make their own copies upon payment of no more than a token royalty. Preparation and transmission of materials over an educational network should be free of copyright consequences. Input and storage in a computer retrieval system should be similarly treated. Educational institutions should have a compulsory license to call forth the data from the computer in whatever form best meets their educational purpose, subject to royalty payment such as is presently made in the sound recording situation."

II.J. PROBLEMS AND PROSPECTS FOR EDUCATIONAL TECHNOLOGY IN THE SCHOOLS: GUIDELINES FOR FUTURE RESEARCH

A study has been undertaken by an economist (E. Greenberg) and an educator (B. Anderson) to examine the costs and benefits associated with the teaching of various subjects with the aid of instructional technology. The study was intended to collect data on the costs associated with

operational systems which use instructional technology to produce a given learning outcome. This data was then to be used to estimate, with more certainty than is currently possible, the costs and benefits associated with a large-scale system which uses instructional technology. Such an approach was deemed preferable to basing a cost-benefit analysis of future educational communications systems on cost estimates for systems which are not yet operational. It was believed that suitable cost-benefit analyses could be available for instructional television, which has been in use for many years.

The areas which seem most promising at the outset was that portion of economics which concerns itself with production functions as well as published literature which might contain careful studies of the costs and benefits of existing educational systems employing instructional technology. Economists have long used production functions to relate the outputs of a given process to various inputs. Recently, the concept has been applied to the field of agriculture and education although the results have been somewhat unsatisfactory as a guide to educators.

Greenberg and Anderson believe that in principle, the estimation of educational production functions at the operational level is not impossible, and probably not more difficult than the estimation of similar functions as derived in agriculture and other industries.

There are, of course, educational outputs which cannot presently be quantified, some of which may never be satisfactorily measured. But many educational objectives, particularly at the elementary and secondary levels, can be and are being measured. In fact, his ability to use experimental techniques makes the task of the educator-statistician more like that of the agricultural economist, who has estimated successful operational production functions for a long time, than that of the general economist attempting to estimate production functions from unplanned experimental data, whose success at developing operational functions has been limited.

The search of the literature led Anderson and Greenberg to conclude that no one had set about to estimate production functions at the level needed. Research directed toward other ends, however, is useful. For example, the vast amount of research which attempted to learn whether TV or a face-to-face lecture were more effective generated much of the

information needed for production function estimation (although the functions were never estimated). The best of these studies, summarized in Dubin and Hedley (1969), were concerned with individual student performance in particular courses. They frequently controlled for student ability in an attempt to isolate the effects of the method used to deliver the lecture. Moreover, several of these research projects went beyond the learning of the particular subject matter to determine whether TV had differentially affected the student's attitudes toward a number of things--that is, an attempt to discover side effects both desirable and undesirable.

In the area of cost-benefit studies of operational instructional technology systems, it was found that there is essentially no information available in the published literature in spite of the large amount of money spent on instructional television in the past. We are currently attempting to obtain such information by visiting appropriate facilities, and we are also planning to analyze Sesame Street data which we hope will be provided by ETS to see whether suitable production functions can be obtained. Performance contracts now ending their first year of operation may also provide us with useful results.

The major conclusions of the Anderson-Greenberg study are:

"1. There is no reason to assume that electronic media cannot deliver education as well as the human medium. Comprehensive reviews of the literature suggests that conventional lessons, delivered by television, are as effective as those delivered in the classroom. The studies seem to show that, as far as achievement test results are concerned, it does not much matter how the message is delivered. Also, it does not seem to make much difference to student attitudes; some students like television, some do not. However students who dislike teachers may like TV and vice versa--so a combination of teachers and TV might reduce dissatisfaction among students.

"2. The preoccupation of researchers with the question of whether media can replace the human teacher as dispenser of information has led them to ignore important questions. Can the electronic media perform the custodial functions or at least help to perform it? (Here is a paradox, for electronic media seem to be able to do the same job as human media, but do it quicker, thus making it harder to keep children in school for as many years as we now do--yet society wants those same children in school.) Can we

organize education and take advantage of media's ability to allow children (and adults) to pick and choose the time and place for education much more freely than they are presently allowed to do? (This is one of the major benefits of supplementing or replacing professional teachers with media. It is a benefit which is rarely sought when schools implement media-based instruction systems.) Can we solve the problem of certifying children without sending them to schools? Many programs aimed at implementing electronic media as educational tools seem to have been overlooked, and fallen on this obstacle. Many people want an education not because of its intrinsic value but because a certificate is awarded at the completion of a program of study.

"3. Four changes are required if instructional technology is to be used in schools. The first is that the states need to collect data about the achievement of pupils in school. Media could then be assessed in terms of their cost-effectiveness for obtaining pupil achievement. At present schools are charged by law with the incarceration of pupils for a certain number of days per year, and for a certain period of time in each of those days. They are also charged with presenting certain objects (such as textbooks) to students, and, in some states, they are told how many teachers there must be for each student. These constraints are put on inputs to the school system in the belief that high quality inputs will produce high quality output. However, no data is collected by any state which would allow us to make assessments about the outputs coming out of any school--thus there is no way to judge cost-effectiveness.

Second, schools must separate the certification function from the teaching-learning process. The simplest and most effective way to do this is to have skill mastery assessed by some agency other than the teacher and school which tried to teach the skill. (C. L. Lessinger, 1970). The old city and state-wide examinations which are now being dropped all across the country should have served this role, especially had they been graded on the basis of objective and absolute standards. School people, by adopting the normal curve in place of objective standards, subjected themselves to the charge that tests were unfair, undemocratic, fostered competition in students, and were generally bad. The response, to abolish rigorous testing altogether, has been reasonable in view of the poor testing

conditions imposed by curves and competitive grading. However, it has made the rules by which one succeeds in school even more ambiguous than they were when normal curves produced uncertainty.

Third, states need to peg financial support of schools into results obtained rather than to numbers of pupils incarcerated, teacher qualifications and financial needs of school districts. This would simultaneously stimulate experiments with different teaching results, eliminate the problems associated with paying teachers by degree and experience rather than by competence, and presumably reduce inequality, since schools located in lower class areas could produce more.

Fourth, schools need to develop management talent in their administrators and teachers. The problem of monitoring student progress, making sure that all students develop to within acceptable limits of quality, and doing both of the above on time and at reasonable cost is a management problem. The conventional wisdom, non-specialized learning content of "human relations" approaches to management found in most schools of educational administration will not do the job.

"4. The paper has demonstrated a glaring need for further research. To determine educational requirements for technology, we need to know much more about how media and teachers can be used together to teach specific subjects. This will first require identification of those subjects which are critical, and then a coordinated research undertaking. It is not enough to spread large amounts of money all over the country. Data from the experience of the United States Office of Education suggests that very large expenditures of money can simply be swallowed up with neither marked increase in pupil performance nor much addition to our knowledge of the educational process. Lessinger (1970) notes that between 1966-70, 4.3 billion dollars were spent on Title I of the Elementary and Secondary Education Act with no measurable results. Much the same conclusion is reached by Westinghouse in its study of Head Start programs (Cicirelli, 1969). In short, there is overwhelming evidence that even large sums of money do not have an impact on the sorts of results that are sought by schools. However, by a research program which is designed to explore input combinations, in a few years time we could learn a great deal about alternative methods of teaching reading, for example, to children of different abilities and backgrounds.

Oettinger's remarks about policies conducive to economically efficient progress are worth quoting:

1. If we want efficiency, we must support promising ideas longer than either private or government programs now permit.
2. If we want efficiency, we must support risk-taking and cushion failure.
3. If we want efficiency, then risks, resources, and responsibilities, the 3 R's of educational technology, must be shared by all the partners in the educational enterprise.
4. If we want efficiency, we must chart our course by human judgement, not exclusively by formula.
5. If we want efficiency, we must follow through in depth with a small number of diverse alternatives.

We need to follow such policies in examining the potential for educational applications of technology. To date, efforts have been too modest, support too small and too short in duration, and, most important of all, the imagination of technologists has been so limited in attempting to redesign educational facilities and services to take advantage of technology, that really serious efforts to introduce technology into education cannot be said to be taking place in American education."

II.K. ANALYSIS AND ESTIMATES OF UTILIZATION RANGES

1. Introduction

In this section we will endeavor to estimate ranges of utilization for various educational telecommunications services of interest for the 1970's and 1980's. Before proceeding, some cautionary words are in order. We consider this to be a first iteration of utilization ranges. We would expect modifications to result after educational users and administrators have had a chance to react.

The utilization which might be achieved in the year 1975 or 1985 will be influenced by a wide variety of factors. These include available budgets for media and technology, political support for media-technology at various implementation levels, the nature and availability of the educational delivery system, the relationship between technology and the teacher and/or

the student, the availability of quality and quantity programming, the impact of copyright legislation; in short, a sizable number of factors, many of which can not be quantified. However, we will endeavor to consider these factors in future analysis.

2. Previous Studies

There are two previous studies which shed some light on how one might proceed.* A study was carried out by the National Academy of Engineering's Commission on Education to test the concept of technology assessment in which the focus was on the technology of teaching aids.^[10] The goal of the study was:

"To assess the promise of various alternative strategies for the development and use of systems of instructional television and computer-assisted instruction at institutions of higher education in the United States, as a means for alleviating rising costs without sacrificing quality of instruction and as a means of reducing or eliminating incidents of student unrest."

The N.A.E. study concluded that, following the development of a data base, the next step was the identification of alternative strategies to solve the two principal problems in higher education outlined above. The level of fiscal support was chosen as the most sensitive parameter for affecting the development and application of the technology and, in particular, the level of federal government support. However, the alternative strategies examined included program emphasis as well as dollars. The strategies considered were as follows:

- "1. Strategy No. 1 assumes that no federal government funding would be available other than that incorporated nonspecifically in the several existing education Acts. The program would be administered on the same bases as now apply, by essentially the same agencies, and at the same level of diversity of projects.
- "2. Strategy No. 2 assumes essentially the same level of funding as does Strategy No. 1, but it would provide for the concentration of the program into relatively few projects with support for each project at a high level. This would represent a strategy alternative based on a variation of program emphasis.

*A third study performed by Lockheed has been summarized in a previous progress report.^[2]

- "3. Strategy No. 3 assumes that a new program of federal support would be initiated and funded at about \$100,000,000 per year. The program would be specifically directed at the support of ITV/CAI technology applications and would be administered by an existing government agency.
- "4. Strategy No. 4 assumes that an all-out approach would be initiated, involving a funding commitment on the order of \$1,000,000,000 dollars per year. It would also provide for the creation of a special agency having the responsibility for the development and extensive introduction of ITV/CAI systems into all institutions of higher education."

The procedure adopted was that for each strategy, the impact on four groups--institutions of higher learning, students, faculty and industry--was assessed with more than one factor examined for each group. Both primary consequences and second order effects were examined. The nature of the impact was evaluated on a 3 point scale as F (Favorable), F (Unfavorable), ? (Unknown). The probability of occurrence of impact was specified as either L (Likely) or U (Unlikely) and the effect of federal action on impact was categorized as C (Controllable), U (Uncontrollable) or ? (Unknown). Impact and characteristics of Strategy No. 1 (Status Quo) are shown in Table 12. Each point is accompanied by a supporting discussion.

Thus, the NAE study provides a method of assessing in a qualitative way, the impacts and characteristics of various strategies related to ITV/CAI utilization on certain outcomes within education. In our own work, we have been more interested at this stage in setting utilization ranges which can then be employed in the systems synthesis phase of the work. Therefore, we have not followed this procedure. The NAE methodology may prove useful in a later socio-economic assessment phase.*

A more directly relevant study has been carried out by an interdisciplinary group sponsored by Bell Canada.^[11] The study, entitled "An Exploration of the Future in Educational Technology", utilized the Delphi Technique to predict when various educational technologies will

*It should also be pointed out that the NAE study concludes that a full technology assessment for all phases of educational technology for use at all levels of education could easily cost between \$500,000 and \$750,000 for a two-year period.^[10]

Table 12

Impacts and Characteristics of Strategy No. 1*

Impacts	Strategy No. 1	
	Primary	Further
Institutions of higher education:		
HE-1 Increased cost.....	F LC	
HE-1.1.....		F LC
HE-2 Improved instruction.....	F LC	
HE-2.1.....		FLC
HE-3 Physical plant modification.....	FLC	
HE-3.1.....		FLC
HE-4 Closer ties between schools.....	F LC	
HE-4.1.....		F LC
HE-5 Destructuring of curriculum.....	F LC	
HE-5.1.....		F LC
HE-6 Extended day, week, and year.....	F LC	
HE-6.1.....		?L?
HE-7 Need for more TV channels.....	F LC	
HE-7.1.....		?L?
HE-8 Standardization and centralization.....	FLC	
HE-8.1.....		FLC
HE-9 Improved continuing education.....	FLC	
HE-9.1.....		FLC
HE-10 Coping with poorly prepared students.....	F LC	
HE-10.1.....		F LC
Students:		
S-1 "Impersonal" education.....	F LC	
S-1.1.....		F LC
S-2 Individualized instruction.....	F LC	
S-2.1.....		FLC
S-3 Aid for minority-group students.....	F LC	
S-3.1.....		F LC
S-4 Student-instructor relationship.....	F LC	
S-4.1.....		F LC
Faculty:		
F-1 Modification of instructor's role.....	F LC	
F-1.1.....		FLC
F-2 New copyright protection.....	F LC	
F-2.1.....		?L?
Industry:		
I-1 Industry-controlled education.....	FLC	
I-1.1.....		?L?
I-2 Development of industries and products.....	F LC	
I-2.1.....		?L?

NOTE.—F=Favorable, ~~F~~=Unfavorable; L=Likely, ~~L~~=Unlikely; C=Controllable, ~~C~~=Uncontrollable; ?=Unknown.

*From NAE Technology Assessment of Teaching Aids for Higher Education[10]

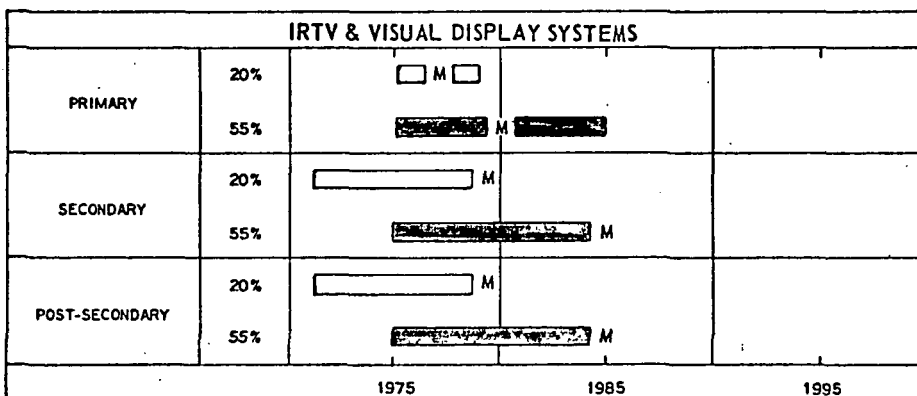
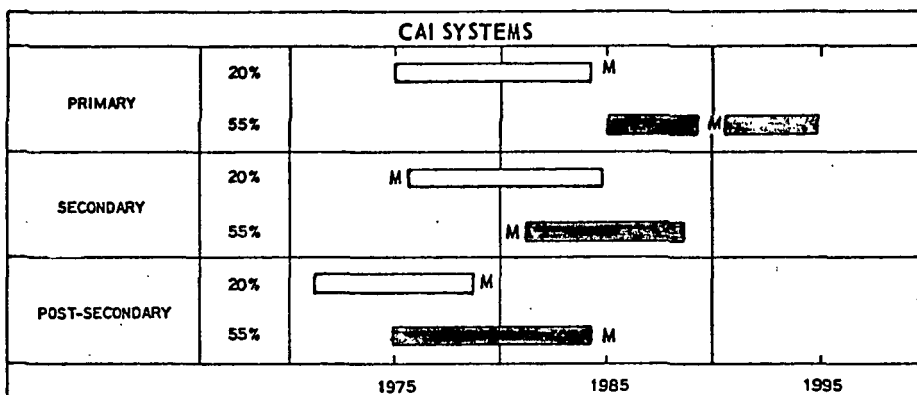
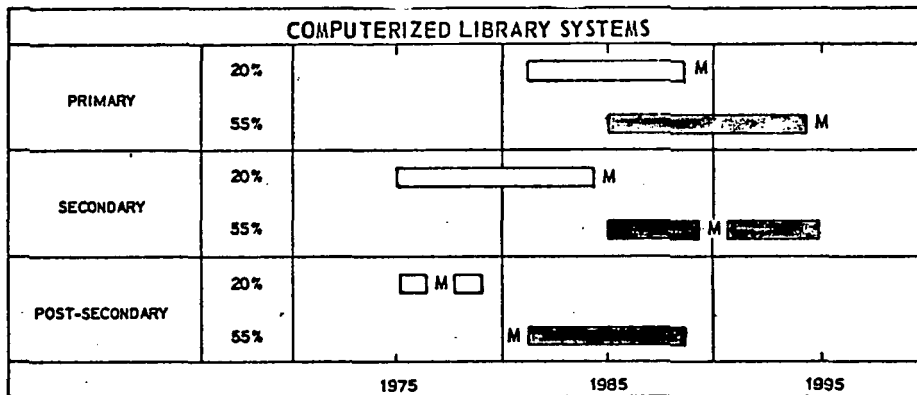
come into certain quantitative levels of use at several levels of education. The technologies considered included computer-aided instruction (CAI), Information Retrieval-Computerized Library Systems (CLS), Audio-Visual Display Devices, (Informational Retrieval Television Systems), Terminals for CAI and/or CLS. Also examined was the diffusion of educational technology into the home.


Figure 18, taken from the Bell-Canada study, shows the predicted likely timing of adoption of three technological systems. The figure bears up a major conclusion of the study, namely that "extensive development and widespread adoption of educational technology will occur during the late seventies and eighties." The conclusion is one of three major trends gleaned from the study. The other two are: "A period of change in education is forecasted during which concepts, curricula, methods and the role of the teacher in the educational process will alter steadily over the next twenty-five years." "The whole society will be in a period of transition. Cultural values will be changing gradually to form a society more open to innovation, more insistent upon involvement and participation, and more oriented to the individual." Thus, the study concerned itself with values and beliefs which might affect the diffusion of technological innovation. Figure 19 summarizes some significant conclusions concerning changes and values of North American Society. Members of the Bell-Canada Study Team were primarily educational researchers, administrators, consultants and technologists.


In our own estimates of utilization to follow, we have not employed the Delphi technique, although it may be very desirable to do so in the future. The results presented are primarily the estimates of two of us, R. P. Morgan and J. P. Singh, although we have had the benefit of advice and feedback from many of our colleagues. In general, we feel that the Bell-Canada Study results may be optimistic concerning the acceptance of educational technology and we have generally tended to view those results as representing an upper limit of utilization. This approach is in keeping with the effort to keep our estimates of educational satellite systems requirements somewhat conservative; that is, we will be predicting less of a demand than the Bell-Canada study seems to indicate.

Figure 18

LIKELY TIMING OF ADOPTION OF
TECHNOLOGICAL SYSTEMS*

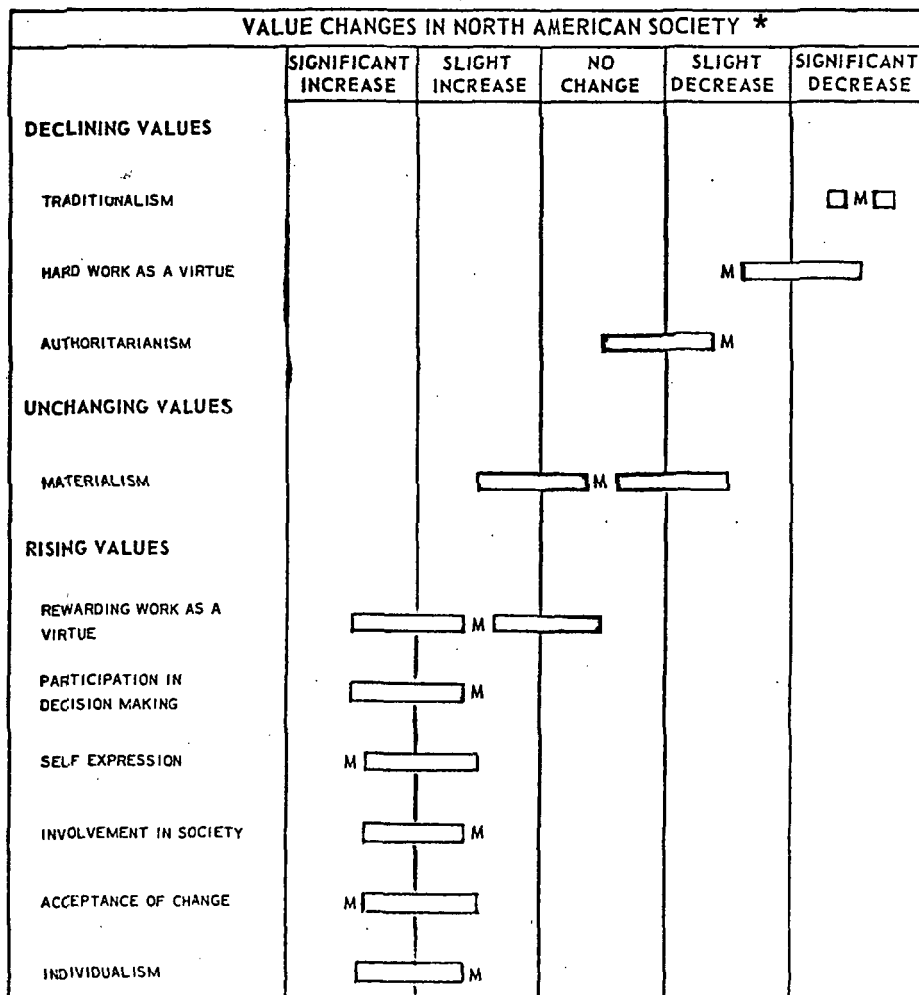


 PERIOD OF SYSTEM REFINEMENT AND EARLY ADOPTION

 PERIOD OF EXTENSIVE ADOPTION

*From Bell-Canada Delphi Study^[11]

Figure 19



*From Bell-Canada Delphi Study^[11]

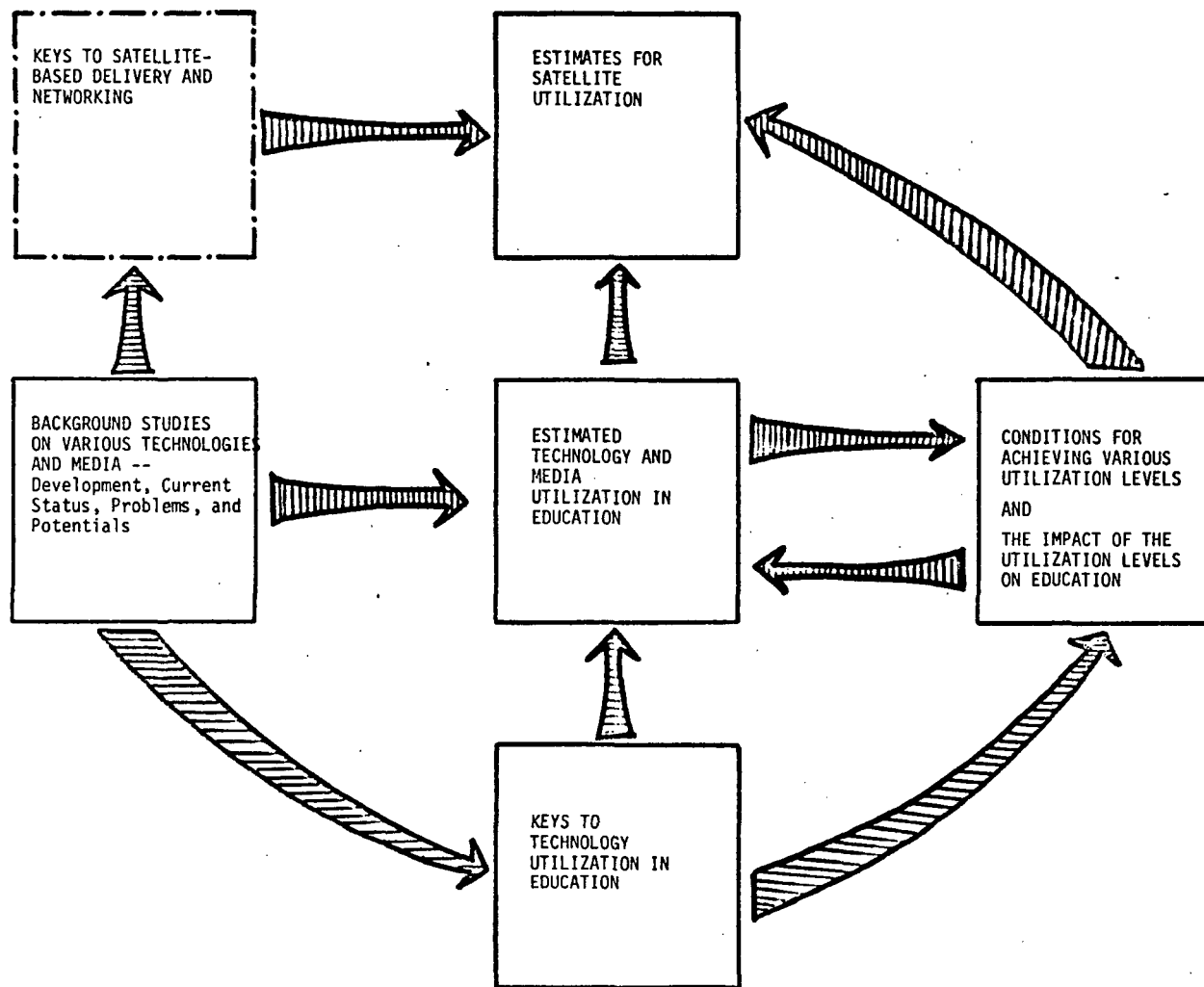
3. Estimates of Ranges for Technology Utilization

The approach we have taken in our efforts to synthesize educational satellite systems has been to base the requirements for such systems upon predictions of future utilization ranges for various educational services at various levels of education. This section constitutes an initial effort to develop those utilization ranges. This work will be continually refined in the course of the coming year as feedback is obtained from various sources, with primary weight being given to the reactions of the educational user community.

Figure 20 illustrates the procedure we have followed in making estimates of satellite utilization ranges. The starting point is the background studies on various technologies and media which were summarized in Section II. Basically, what we have done is to make certain "educated guesses" of ranges of utilization of technology and media in education which might be possible in 1975 and 1985, based upon the background studies. These latter studies have also provided useful information of direct value in the satellite-systems synthesis work and in future socio-economic impact studies, as is depicted by the flows on the diagram leading to "Keys To Technology Utilization in Education" and "Keys To Satellite-Based Delivery and Networking".

In addition, to estimating ranges of media-technology utilization, it is necessary to estimate what subset of this overall utilization is likely to make potential use of satellite-based service. This latter set of estimates derives from a number of sources of information, as is depicted in Figure 20. The complexity of the type of analysis we have attempted is illustrated by the fact that the desired estimates will also be affected by both an analysis of conditions for achieving various utilization levels and an analysis of the impact of these levels upon education. These latter two factors have not been included to any extent in the results which follow but will be given careful attention in the future.

Table 13 presents estimates of technology utilization in education for the years 1975 and 1985, along with estimates of the percentages of the total institutional population likely to make potential use of satellite based services. The services for which estimates have been made fall into



PROCEDURE FOR OBTAINING SATELLITE UTILIZATION ESTIMATES

Figure 20

Table 13

ESTIMATES OF TECHNOLOGY UTILIZATION IN EDUCATION; 1975; 1985;
WITH ESTIMATES OF POTENTIAL SATELLITE UTILIZATION

SERVICE		PERCENTAGE UTILIZATION						PRIMARY ROLES FOR SATELLITES	PERCENT OF THE POTENTIAL USER INSTITUTIONAL POPULATION LIKELY TO MAKE USE OF SATELLITE-BASED SERVICES		
		1975			1985				ELEMENTARY EDUCATION	SECONDARY EDUCATION	HIGHER EDUCATION
		ELEMEN- TARY ED.	SECOND- ARY ED.	HIGHER EDUCATION	ELEMEN- TARY ED.	SECONDARY EDUCATION	HIGHER EDUCATION				
INSTRUCTIONAL TELEVISION [ITV]#		3 - 6	4 - 8	5 - 10	4 - 20	4 - 25	5 - 20	DIRECT DELIVERY TO SCHOOLS; TO BROADCAST STATIONS, AND ITFS AND CABLE HEADENDS FOR FURTHER REDISTRIBUTION.	40 - 90	40 - 90	20 - 50
COMPUTER-AIDED INSTRUCTION [CAI]#		0.1 - 2	0.3 - 2	1 - 3	1 - 10	5 - 20	5 - 20	DELIVERY OF CAI TO SMALL, REMOTE INSTITUTIONS, PARTICULARLY THOSE 70-80 MILES OR MORE AWAY FROM A MAJOR METROPOLITAN AREA.	15 - 30	15 - 30	5 - 10
COMPUTING RESOURCES	MULTI-ACCESS INTERACTIVE COMPUTING	4 - 10	5 - 12	15 - 30	8 - 20	15 - 50	50 - 80	DELIVERY OF INTERACTIVE COMPUTING TO REMOTE INSTITUTIONS FOR THE PURPOSES OF PROBLEM SOLVING, EIS, ETC.	15 - 30	15 - 30	10 - 20
	BATCH PROCESSING [Including Remote-Batch]*	7 - 35	30 - 50	65 - 75	15 - 70	50 - 80	80 - 100	DELIVERY OF RAW COMPUTING POWER TO SMALL, ISOLATED, AND REMOTE INSTITUTIONS FOR INSTRUCTION, ADMINISTRATIVE DATA PROCESSING ETC.	20 - 30	20 - 30	2 - 5
	COMPUTER INTERCONNECTION*	0+	0+	0.8 - 2	0+	5 - 10	10 - 20	INTERCONNECTION OF CAMPUS COMPUTING FACILITIES FOR RESEARCH RESOURCE SHARING; OF CENTRALIZED REGIONAL COMPUTING NETWORKS FOR LOAD AND SPECIALIZED PROGRAM SHARING.	40-80 % of Regional Computing Networks 60 - 80 % of Campus Computing Facilities (Higher Education)		
INFORMATION RESOURCE SHARING	INTERLIBRARY COM. -- TWX, FACSIMILE*	0	0+	10 - 20	0.5 - 1	2 - 5	20 - 40	FOR BIBLIOGRAPHIC SEARCH, INTER-LIBRARY LOANS, ETC.	5 - 10	25 - 40	40 - 70
	AUTOMATED REMOTE INFO. RETRIEVAL*	0	0+	0.8 - 2	0	0+ - .5	2 - 5	FOR REMOTE INFORMATION RETRIEVAL, AUTOMATED BIBLIOGRAPHIC SEARCH FROM SPECIALIZED CENTERS.	0	1 - 10	40 - 70
	TELECONFERENCING* [Long Distance]	0+	0+	4 - 6	0.5 - 2	0.5 - 2	6 - 10	FOR ACCESS TO SPECIALISTS IN DISTANT AREAS	3 - 10	3 - 10	10 - 30

Percentage Expressed in Terms of Time Spent By Student in Classroom.

* Percentage of Total Educational Institutions having This Capability.

† Interconnection Among Centralized Computing Networks May Develop during 1975+.

four main categories; Instructional Television, Computer-Aided Instruction, Computing Resources (excluding CAI) and Information Resource Sharing. Separate estimates are included for each of three educational levels: elementary, secondary and higher education.

In what follows, a brief justification for these estimates will be presented and additional information presented which will be of use to the systems designer. Also included is a discussion of Public Television and Radio services which, although they do not lend themselves readily to the format of Table 13, represent a major component of potential satellite-based educational system services. Omitted from Table 13 but of potentially great importance are estimates for services to be delivered to homes and other learning centers* instead of to schools. Home delivery and other out-of-school services require separate consideration in themselves.

For all the categories of Table 13 except ITV and CAI, it is necessary to know the actual extent of utilization in terms of time and information rates. These estimates are currently being made.

We fully expect the estimates in Table 13 to be different three or six months from now. They are a first rough cut. Furthermore, some people may question whether such numbers can in fact be used at this stage (or any stage, for that matter) to serve any useful purpose. It is our belief that they do in fact serve a useful purpose. They give some basis, other than verbal speculation, for examining whether an educational satellite system makes sense. They should at least provide an order of magnitude estimate of requirements for an educational satellite system so that one can decide whether further work on the concept is desirable. At best, if the estimates prove reasonably accurate, they can be used to help define alternatives for educational satellite systems with some degree of realism.

a. Public Television and Radio

In contrast to the other service segments considered in this study, requirements for public television and radio, at least in the short run, can be fairly well defined from the point of view of the user community.

*Estimates for Vocational, Special and Continuing Education have not yet been made and will be considered in future work.

This situation exists because there are organizations, namely Public Broadcasting Service and National Public Radio, which provide a framework for nationwide distribution of services. The requirements as set forth by these organizations have been summarized in response to recent filings by commercial firms before the Federal Communications Commission to own and operate domestic satellite facilities. Tables 3 and 4 summarize these requirements.

In the longer run, it may be desirable for public television to establish a second network service. Because of restrictions on the number of ETV outlets in a city, this service could very well be based upon the use of cable-TV outlets interconnected by satellite. Conditions for the growth and development of public television would appear to be very favorable, more so than at any time in the past.

One important question which requires careful study is the future role of Public Broadcasting in in-school instruction. Although CPB and PBS have made certain studies and have taken certain specific steps (Electric Company ?) in this direction, there may still be opposition to CPB-PBS moving into this area.* However, counterbalancing this is the widespread acceptance of programs such as Sesame Street which profit by a national delivery system such as PBS provides. There is considerable interest now being shown in the "University of the Air" concept for home viewing.

Public television and radio represent important segments of a potential educational satellite system. Their short term needs are reasonably well defined, in contrast to other educational services. They have shown major interest in capitalizing upon satellite technology. They will very likely have a pivotal role in determining whether an educational satellite system will fly or not. If they throw in with commercial companies, it may very likely be not.

*Opposition was expressed in testimony on the new Public Telecommunications Act.[12]

b. Instructional Television

There are two numbers which are of great importance in estimating requirements or opportunities for instructional television; the average classroom time in which television is used and the software production costs. Both of these numbers are difficult to pin down and there is considerable disagreement on possible values.

Average classroom utilization of television at all levels in education is currently estimated to be less than 5% of total classroom time. A study of instructional television utilization in 16 urban centers indicates that this figure is more nearly 3%. By contrast, figures chosen for future oriented cost analyses assume an increase to from 10% (Sovereign) to 20% (Barnett and Denzau) to 33-1/3% (DuMolin and Morgan).

In terms of educational level, there would appear to be a steady or slightly upward trend in higher education with state university networks coming into being. At the elementary and secondary levels, budget restrictions are probably limiting growth, with an important new factor being nationally distributed programming of the "Sesame Street", "Electric Company" variety. It is likely therefore that, given roughly the status quo, utilization will not decrease but that gains will come primarily in higher education (University of the Air) or through media that are not designed exclusively for "in-school" use.

Therefore, for future requirements, we choose the ranges of classroom utilization shown in Table 13.* The higher range estimates are not likely in our opinion, unless cost-benefit demonstrations are held or can be documented which are convincing to school-boards or unless there are considerably increased federal funding inputs. Increased flexibility and program choice through use of video-cassette players and cable-TV may provide new incentives for better use of the ITV medium.

Only a fraction of the overall utilization need necessarily be distributed by long-distance telecommunications. Although there is a strong trend away from local production of instructional materials, both CCTV and ITFS still make heavy use of local production with about half of these programs in this category. Higher education is a heavy user of CCTV with

*The Bell Canada Delphi study predicts large-scale (55%) usage of information-retrieval television systems during the period 1975-1985.

ITFS favored by parochial schools. However, the satellite fraction could be a large fraction for these particular programs (science and mathematics, current events) which are universal in language and can be distributed widely. Such distribution can take place not only to rural schools but to urban centers as well via cable TV headends and ITFS. Hence, we have indicated fairly large numbers on the right-hand side of Table 13 for Instructional Television.

As far as program production costs are concerned, all evidence points to the desirability of increasing instructional television programming budgets from their very low initial levels to those more nearly approaching commercial TV. The current Sesame Street program production costs of \$40,000 per hour probably represents the high end of the range but costs on the order of \$10,000 per hour would not seem unreasonable. A range of from \$2,000-\$40,000 probably would be all-inclusive for nationally distributed programming. If these large programming costs can be spread out over large user populations, the economics for utilization becomes more favorable. Long-distance electronic delivery via satellite offers the potential for rapid, wide-spread distribution. This must be balanced against local needs and requirements, and the organizational and administrative problems associated with running a large-scale distribution system.

c. Computer-Assisted Instruction

Although CAI has served well as a research and demonstration tool, it is still in its infancy. Current CAI applications and experiences are mostly experimental in nature. Like any other developing technology, they have been primarily prompted by various research groups, interested in the hardware as well as software aspects of CAI research and development. According to one estimate, the number of students receiving a significant portion of instruction in at least one subject under computer control is still countable in only the few thousands. In 1968, some 500 institutions were reported as having some sort of CAI capability--less than 1% of the total institutional population. Though CAI systems clearly hold great promise for higher education from the viewpoint of economics, the majority of the institutions that have benefitted from CAI so far have been secondary and pre-secondary.

The future of CAI in all levels of instruction is dependent upon the lowering of the hardware cost, development of adequate quality software, realization of certain standardization among various CAI systems being marketed or that will enter into market in future, level of educational funding, emphasis on the individualization of instruction, and reduction in the communication costs. Much will also depend upon the introduction of necessary institutional reforms that will eliminate the lock-step educational process and help in the realization of the full cost-benefit potentials of CAI. Lowering of hardware cost is foreseeable from two major sources: (1) Developments in computer technology that will permit reduced costs; and (2) Utilization schemes that would allow rather intensive utilization of system hardware--terminals, central processing units and other peripheral equipment--to spread the hardware cost over a larger number of users.

It is impossible to forecast the developments in computer-technology over a long period of time. Many of the innovative leaps that have characterized developments in the computer industry have escaped long-range predictions. Assessment of impacts of future developments in computer-technology on instructional usage would have to be based upon those developments that are beginning to have their impact. It is not likely that demands for computers in education would significantly affect the broad course of development in computer technology, except in a few areas such as terminal design. The hardware development that may have a profound effect on future CAI development are: (1) Large Computers such as Illiac IV and Control Data STAR; (2) Minicomputers; and (3) Terminals.

Because of the economies of scale in computing, the future for large computers seems certain. Of special importance is the micro-programming capabilities of large computers that allow a diversity of tasks to be performed essentially concurrently. This will allow a large number of CAI lessons to be run simultaneously. In addition, large computers will be capable of handling a large variety of systems, languages, and data files and thus provide their users with a variety of services. However, at present the efficient usage of these future "super-computers" is not understood and it would not be possible to define their impact in exact words. Competing against large computers for CAI, would be small general purpose electronic computers, often called "minicomputers". These computers

were introduced in the late 1960's and were originally priced between \$10,000 and \$25,000. By 1980, it is expected that they may cost no more than \$2,000 complete with an input unit and a TV-like display. It is conceivable that computer-lessons on "cassettes" would be available in the late 1970's or early 1980's in a fashion similar to books and would promote "personal" computers. However, in an institutional set-up, the personalization of CAI in terms of hardware with associated limited capabilities would have to be weighted rather carefully against the advantage offered by centralized "superfacilities" in terms of flexibility, institutional barriers, and system economics.

Currently the most economical terminal is teletype but it has rather limited instructional capabilities. Developments like the plasma-panel are expected to reduce the cost of display terminals substantially and make them more economically attractive and expand the applications areas. Other developments in terminals that are likely to favorably affect the situations are related to cheaper means of pictorial input and interpretation.

In the next ten years, one may also expect development of simple as well as powerful languages permitting their use for people with little or no programming experience. These simple languages will be subsets of English and would permit substantial reductions in the writing of CAI lessons.

Based on these and various other factors listed earlier, we have estimated the utilization of CAI (See Table 13). In the next ten to fifteen years, we expect the beginning of a period of extensive utilization and the termination of a period of system refinement and early adoption. Higher education will be the first level to use CAI extensively and will lead in its utilization. Primary areas of CAI application are likely to be those with a highly structured nature such as mathematics, sciences, etc.

Table 13 also provides estimates for the utilization of satellites for the delivery of CAI. As discussed, the primary role for satellite is going to be in the delivery of CAI services to remote institutions. In this respect it will have to compete against the alternative offered by a minicomputer. However, the advantages of a greater variety of services including raw computing power (batch as well as interactive) and languages offered by interconnection to a supercomputer are likely to have their own attractiveness. The decision for satellite-based delivery will also

depend upon the terminal population that is to be served at a particular location as well as the nature of the terminals in use and the separation between the computer and the terminal cluster. If the terminal cluster is composed entirely of teletypes requiring low data-rate inputs, the satellite-based service would not be economically viable for interconnection distances less than 200-300 miles depending upon the cluster as well as overall terminal population. If the terminals have a display capability requiring relatively high data-rate inputs (few kilobits/second), the satellite-service or interconnection may become viable for distances as short as 40-60 miles. These uncertainties are reflected in the wide-ranges quoted in Table 13 for potential satellite utilization.

d. Computing Resources

Computers have gained a fairly good acceptance in education for a variety of applications ranging from administrative data processing to interactive problem solving and information retrieval (See Figure 13). Computer use is substantial among institutions for higher education, particularly those offering doctoral programs and having large enrollments. Some 50-55 percent of the institutions for higher education are supposed to have some kind of access to electronic computers--via campus computing facilities, time-sharing vendors, or regional cooperative arrangements. The extent of computer usage in secondary schools is fairly high. In a recent survey conducted by AIR, some 34.4 percent of schools responding to the survey reported some type of computer use. Whereas in higher education, computer utilization is rather evenly divided among administrative, instructional and research applications, computer utilization in secondary institutions is predominantly administrative. In addition, the user schools are clustered around major metropolitan areas.

It is very clear that computer utilization in education will continue to grow in terms of institutions having access to it, time available to individual students, as well as in terms of applications. The growth rate will be a function of the developments in computer technology that bring about a reduction in computation cost, the money supply, and the emphasis on providing equitable access to all students irrespective of where they are located. As discussed in the earlier section on Computer-Assisted

Instruction, supercomputers such as CDC STAR and Illiac IV hold special promises for educational users in the coming decade. Remote computing networks based on supercomputers not only promise economies of scale and specialization but also are capable of providing a large selection of languages and systems that no ordinary institution could afford in a campus facility. The future of remote computing networks is definitely bright in situations where the basic need is the delivery of raw computing power (a great deal of power but for relatively few applications) and not enough to justify dedicated campus based facilities.

In addition to the centralized delivery of the basic computer power to institutions that are unable to afford it on a dedicated basis or whose demands (nature as well as quantity) exceed what they can obtain through a small or minicomputer, the development of distributed networks is also foreseen where campus or regional computing centers would be connected among themselves. Interconnection of computing centers themselves will offer network members access to all specialized facilities--both hardware and software--located throughout the network. Another approach to computer network development may involve small, local computers for most needs, but with the capability of tying-in with larger, remote computers when required. This involves a blend of several features--minicomputers, supercomputers, time-sharing, remote batch, and communications--and, in the future, may well be a common way of organizing and distributing computing power. Such an approach not only promises access to specialized hardware and software that may be prohibitive to develop at each individual location but also provides for the possibility of sharing the load with the remote computer during peak hours. Figure 21 shows a possible course of development for distributed networks.

Table 13 shows our estimates for the ranges of computer utilization at various levels of education for 1975 and 1985. Some may dispute the figures given for multi-access interactive computing for pre-secondary institutions as being on the higher end. However, if one looks at the growing demands for accountability in education, particularly at the school level, and the recent developments in Education Information Systems (EIS), the ranges quoted become more plausible. As far as the interconnection of campus computing facilities is concerned, we expect the

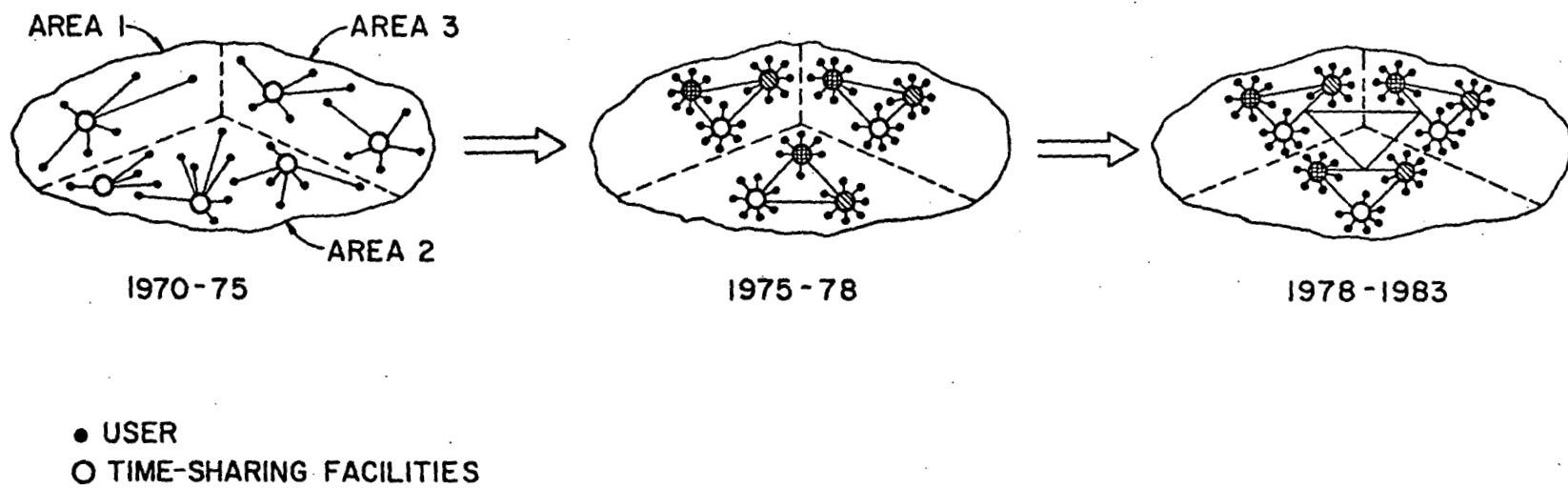


Figure 21. Evolution of Distributed Computer Networks

developments to take place primarily at pioneering campuses in the near-future. In 1985, it is quite likely that computer interconnection would also reach secondary institutions. However, the primary focus for computer interconnection is expected to remain research oriented in the next five to seven years.

Primary roles for satellites are expected to be towards the delivery of computing power to remote and small institutions and interconnection of computing facilities separated by substantial distances. The minimum distances for which satellite interconnection becomes economically viable is again a function of the satellite and earth-terminal characteristics, data transmission rates involved, total terminal population, and average cluster population. These uncertainties again lead towards a range for future satellite utilization instead of fixed-point estimates.

e. Information Resource Sharing

An area for study which is currently underway in our program is that of information resource sharing, in which we include interlibrary communication, automated remote information retrieval and teleconferencing (See Table 13). Most of the anticipated utilization for 1975 and 1985 is at the higher education level. The 10-20% figure for 1975 inter-library communication is primarily for teletype messages via TWX. Reduction of communications costs will be required if telefacsimile services are to be used to any extent.

Although estimated utilization is generally small, this could be an important area for the future, particularly for higher education. The figures do not reflect the interrelation between academic needs and certain specialized library resource services which either are extant or rapidly coming into being.

III. COMMUNICATIONS TECHNOLOGY STUDIES

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III.A. INTRODUCTION

A variety of studies have been and are being carried out in this category for the purposes of providing inputs to the systems synthesis and to generate new knowledge which may prove useful in future applications of satellite technology. Three master's theses were completed during the spring and summer of 1971. These include:

1. "Communication Media and Educational Technology: An Overview And Assessment With Reference To Communications Satellites" by H. M. Ohlman (Applied Mathematics and Computer Science)
2. "Still-Picture Television (SPTV) Transmission" by G. M. Sharma (Electrical Engineering)
3. "Wideband CW Microwave Amplification Using Gunn Effect Devices" by A. Sene (Electrical Engineering).

Key results from the above studies were presented in the November, 1970 Progress Report and are available elsewhere. [13-15]

In this report, we will focus upon three study areas in which work is underway and which we have not reported upon previously. In Section III.B., further exploratory work on Gunn Effect devices with emphasis on their potential as switching elements is described. This is followed in Section III.C. by presentation of work performed to date on the design and development of TV receiver front ends for direct satellite reception at 12 GHz. In this latter section, the preliminary design of a new multi-channel receiver which can be used at the headend of a cable television system is described. The development of such a receiver is believed to be an important element in future combined satellite-CATV systems for education. Finally, in Section III.D., some results are presented of operating frequencies for educational satellite systems. Much of this latter study is directly relevant to the satellite systems synthesis work in Section IV.

III.B. CW GUNN EFFECT DEVICES AS SWITCHING ELEMENTS

As interest has grown in the use of microwave digital communication links, the need for high speed, high power microwave switching elements has become apparent. In an attempt to address this problem, Hurtado and Rosenbaum have studied the application of CW Gunn effect diodes as microwave switching devices.

The Gunn effect is a phenomenon observed in certain semiconducting crystals in which dc power applied to the sample is converted directly to microwave power. Oscillators and amplifiers built using these devices have already had an important impact on the microwave communications industry.

The terminal current-voltage (i-v) characteristic of a CW Gunn effect diode is linear until a threshold voltage (v_t) is reached. For higher voltages the current decreases as the voltage increases; that is, the device presents a stable differential negative resistance to its terminals:

$$\frac{\Delta i}{\Delta V} < 0 \quad v > v_t$$

At sufficiently high applied voltage the current again increases. This so-called "N shaped" i-v characteristic, reminiscent of a tunnel diode, for example, can be used to provide two stable bias states. A dc load line passed along the characteristic can be made to intersect it just below threshold and over again in the higher voltage increasing current region.

Hurtado and Rosenbaum have successfully demonstrated that the reduction in the high field mobility of GaAs caused by thermal dissipation in the diode gives rise to this stable differential negative resistance characteristic. They have used this characteristic, for the first time, to obtain a current controlled bi-stable flip-flop. The maximum switching rates were 10 MHz and the peak powers switched were about 300 mW. This concept has the interesting feature that in the high voltage state a CW microwave signal is produced. This allows the state of the flip-flop to be read externally, and opens the possibility of integrating these devices for microwave frequency logic operations. Details of the work are described in a recent memorandum.^[16]

III.C. MULTI-CARRIER 12 GHz DOWN-CONVERTER FOR CATV HEAD-END APPLICATIONS

If satellite-based communications systems are to have wide acceptance in future applications to public education, these systems will have to provide a diversity of programming. Thus a large channel capacity will be needed eventually. One technical approach to achieve large channel capacity in a potentially low-cost system is to use multiple-carrier frequencies, each at a modest transponder power level, and to further utilize the bandwidth of each carrier by multiplexing additional channels. A typical application might involve a ground-station with a multi-carrier receiver simultaneously receiving n independent TV equivalent bandwidth signals, remodulating these signals and distributing them via CATV to subscribing school districts, commercial customers, etc.

Newman, Rosenbaum and Singh have begun the design and development of a multi-carrier down-converter in order to understand better the technical problems involved and to attempt to solve them. The receiver specifications listed in Table 14 resulted from a detailed systems analysis of a receive-only terminal based on the current state of the art. A block diagram of a proposed ground terminal incorporating this down-converter is shown in Figure 22.

A down-converter package has been designed and fabricated. The signal and LO input ports are X-band waveguide. Waveguide-to-coax-to-microstrip transducers deliver these signals to a microstrip mixer board where the LO and signal frequencies are diplexed and mixed in a single ended diode mixer. The mixer has been implemented using packaged, field-replacable diodes in a coaxial mount. The required sum and image rejection filters are contained on the microstrip board. Figure 23 shows a photograph of the down-converter package.

A coaxial test mount was built and tested. It delivered usable performance over a 2 GHz bandwidth, from 10.4-12.4 GHz. Modifications were made and a final version was designed as part of the down-converter package.

The various filters have been designed in microstrip and are currently being evaluated individually prior to their incorporation in the final microstrip board. Design details are given in the study Memorandum.^[17]

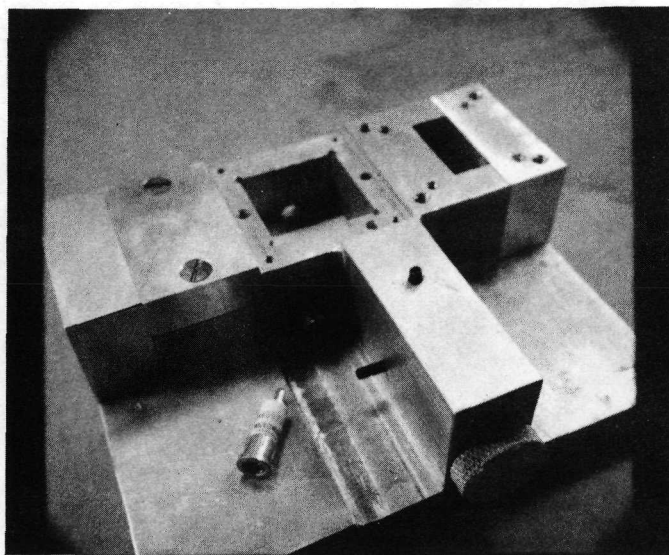


FIGURE 23. DOWN CONVERTER PACKAGE

Table 14

Down-Converter Specification

Center Frequency	11.950 GHz
Bandwidth	500 MHz
Individual RF Carrier Bandwidth (per TV Channel)	36 MHz
Intercarrier Spacing	40 MHz
Modulation	FM
No. of Channels	12
Mixer Noise Figure	11 dB
Conversion Loss	-6 dB
L.O. Frequency	11 or 13 GHz
L.O. Type	Low Noise Gunn Oscillator
Signal/L.O. Input	X-band Waveguide
IF Input	OSM
IF Frequency	1 GHz
IF Bandwidth	500 MHz

The performance of the down-converter will be evaluated upon its completion. Problems which we wish to explore, using this package as a vehicle include: a) intermodulation distortion due to the simultaneous reception of multiple carriers; b) wide-band noise measurements; c) local oscillator stability and noise requirements; d) performance variation with temperature; e) phase and gain distortion.

In order to complete the entire receiver the following components will need to be developed: a) a multi-carrier IF (1 GHz) branching network to separate the individual down-converted signals and to deliver them to the appropriate second mixer; b) the second mixers, their local oscillators, and the second IF amplifier limiter discriminator chain. This development is discussed in detail in the Memorandum.^[17]

III.D. OPERATING FREQUENCIES FOR EDUCATIONAL SATELLITE SERVICES

A study has been completed by J. P. Singh on operating frequencies for educational satellite services.^[18] Included are detailed discussions on International and Regional Frequency Allocations (1963 EARC and 1971 WARC), natural and man-made environmental effects and their frequency dependence, hardware considerations, and interconnection and spectrum space considerations. Various options have been compared on the basis of the continuing analysis of educational telecommunications needs.

The study recommends that education interests should look to the 2.5 GHz and 11.7-12.2 GHz frequency bands to meet their needs. It is further recommended that education interests should attempt to persuade the FCC to remove any service restrictions on 2.5 GHz band (2500-2690 MHz) because retention of the "Broadcast-Satellite Service only" limitation as established at WARC would severely restrict the nature of satellite-based services that could be accommodated in this band. The importance of the 2.5 GHz frequency band for various types of interactive communication is pointed out in the study-memorandum and the limitations of accommodating these services in the 12 GHz frequency band are examined. A 2.5 GHz and 12 GHz combination is recommended in case the telecommunications demands exceed the capacity of the 2.5 GHz band. It is argued that in situations where a common earth-terminal must handle two different frequency

bands, the colocation problem would be severely compounded with any other combination in the frequency spectrum of near-term interest.

Table 15 shows the frequency allocations for the 1963 Extraordinary Administrative Radio Conference for the Communication-Satellite Service (now known as Fixed-Satellite Service) whereas Table 16 shows 1971 World Administrative Radio Conference (WARC) frequency allocations for the various ITU regions. Figure 24 shows Power-Flux Density (PFD) limits for the various downlink frequencies as a function of earth-terminal antenna elevation angle. No PFD limit for the 11.7-12.2 GHz frequency band for either the Fixed-Satellite Service* (FSS) or Broadcast-Satellite Service† (BSS) is shown because the WARC resolutions do not contain any. The advantages of 2.5 GHz and 12 GHz frequency bands in terms of small earth-terminal operation can be seen from Figure 25.

Frequency-dependent natural-environmental phenomena have been divided into two categories and discussed in detail in the memorandum for the frequencies of interest: (1) those that are related to the propagation of the electro-magnetic waves such as attenuation, wave distortion, and polarization-plane rotation; and (2) those that contribute to the overall system noise. A large number of published papers and reports are surveyed

*1971 World Administrative Radio Conference (WARC) just concluded, has renamed Communication-Satellite Service as Fixed-Satellite Service (See Section 2.2.2 of Reference 18). Fixed-Satellite Service is a space service for point-to-point communication between fixed earth stations via active/passive satellites. By the virtue of the altitude of the satellite, this service is also capable of distributing program material over a wide area for rebroadcast purposes.

†Broadcasting-Satellite Service (BSS) is a space service in which signals transmitted or retransmitted by space stations (satellites) are intended for direct reception by the general public. BSS can be divided into two distinct categories: (1) systems that allow individual reception; and (2) systems which are designed for community reception. In the case of individual reception or direct-to-home type BSS systems, the strength of the emissions from the satellite is strong enough to allow reception through simple domestic installations. Community reception-type BSS systems are designed for reception by receiving equipment which in some cases may be large installations and have large antennae and are intended (1) either for group receiving and/or listening, or (2) for local distribution of signals by cable, including CATV installations, or (3) in some cases for rebroadcasting to limited areas.

Table 15

EARC COMMUNICATION SATELLITE FREQUENCY ALLOCATIONS (MHz)

	Region 1 Eurasia and Africa	Region 2 The Americas	Region 3 Australasia
satellite to earth	3400-2600 FIXED MOBILE COMMUNICATION-SATELLITE Radiolocation	3400-3500 RADIOLOCATION COMMUNICATION SATELLITE Amateur	
	3600-4200 FIXED COMMUNICATION-SATELLITE Mobile	3500-3700 FIXED MOBILE RADIOLOCATION COMMUNICATION-SATELLITE	3500-3700 RADIOLOCATION COMMUNICATION-SATELLITE Fixed Mobile
		3700-4200 FIXED MOBILE COMMUNICATION SATELLITE	
earth to satellite	4000-4700 FIXED MOBILE COMMUNICATION-SATELLITE		
earth to satellite	5725-5850 RADIOLOCATION COMMUNICATION-SATELLITE Amateur		
	5850-5925 FIXED MOBILE COMMUNICATION-SATELLITE		5850-5925 FIXED MOBILE COMMUNICATION-SATELLITE Radiolocation
	5925-6425 FIXED MOBILE COMMUNICATION-SATELLITE		
satellite to earth and passive	7250-7300 COMMUNICATION-SATELLITE		
	7300-7750 FIXED MOBILE COMMUNICATION-SATELLITE		
earth to satellite	7900-7975 FIXED MOBILE COMMUNICATION-SATELLITE		
	7975-8025 COMMUNICATION-SATELLITE		
	8025-8400 FIXED MOBILE COMMUNICATION-SATELLITE		

Table 16

WARC COMMUNICATION SATELLITE FREQUENCY ALLOCATIONS [MHz]

Region I Eurasia and Africa	Region II The Americas	Region III Australias
620 - 790 Broadcasting Satellite [Footnote]		
2500 - 2690 BROADCASTING SATELLITE* [Shared]	2500 - 2535 FIXED-SATELLITE (Space-to-Earth) BROADCASTING SATELLITE* [Shared]	
	2535 - 2655 BROADCASTING SATELLITE* [Shared]	
	2655 - 2690 FIXED-SATELLITE (Earth-to-Space) BROADCASTING SATELLITE* [Shared]	
	6625 - 7125 Fixed-Satellite (Space-to-Earth) [Secondary Basis] Brazil, Canada, & USA	
10950 - 11200 FIXED-SATELLITE [Shared] (Space-to-Earth & Earth-to-Space)	10950 - 11200 FIXED-SATELLITE [Shared] (Space-to-Earth)	
11450 - 11700 FIXED-SATELLITE [Shared] (Space-to-Earth)		
11700 - 12500 BROADCASTING SATELLITE [Shared]	11700 - 12200 FIXED-SATELLITE (Space-to-Earth) BROADCASTING SATELLITE [Shared]	11700 - 12200 BROADCASTING SATELLITE [Shared]
12500 - 12750 FIXED-SATELLITE[Shared] (Space-to-Earth & Earth-to-Space)	12500 - 12750 FIXED-SATELLITE [Shared] (Earth-to-Space)	
1400 - 14500 FIXED-SATELLITE [Shared] (Earth-to-Space)		
11700 - 19700 FIXED-SATELLITE [Shared] (Space-to-Earth)		
19700 - 21200 FIXED-SATELLITE (Space-to-Earth)		
22500 - 23000 BROADCASTING SATELLITE [Shared]		
27500 - 29500 FIXED-SATELLITE [Shared] (Earth-to-Space)		
29500 - 31000 FIXED-SATELLITE (Earth-to-Space)		
40000 - 41000 FIXED-SATELLITE (Space-to-Earth)		
4100 - 4300 BROADCASTING SATELLITE		
50000 - 51000 FIXED-SATELLITE (Earth-to-Space)		
84000 - 86000 BROADCASTING SATELLITE		
92000 - 95000 FIXED-SATELLITE (Earth-to-Space)		
102000 - 105000 FIXED-SATELLITE (Space-to-Earth)		
140000 - 142000 FIXED-SATELLITE (Earth-to-Space)		
150000 - 152000 FIXED-SATELLITE (Space-to-Earth)		
220000 - 230000 FIXED-SATELLITE (Transmission Direction Unspecified)		
265000 - 275000 FIXED-SATELLITE (Transmission Direction Unspecified)		

*For Community Reception Only.

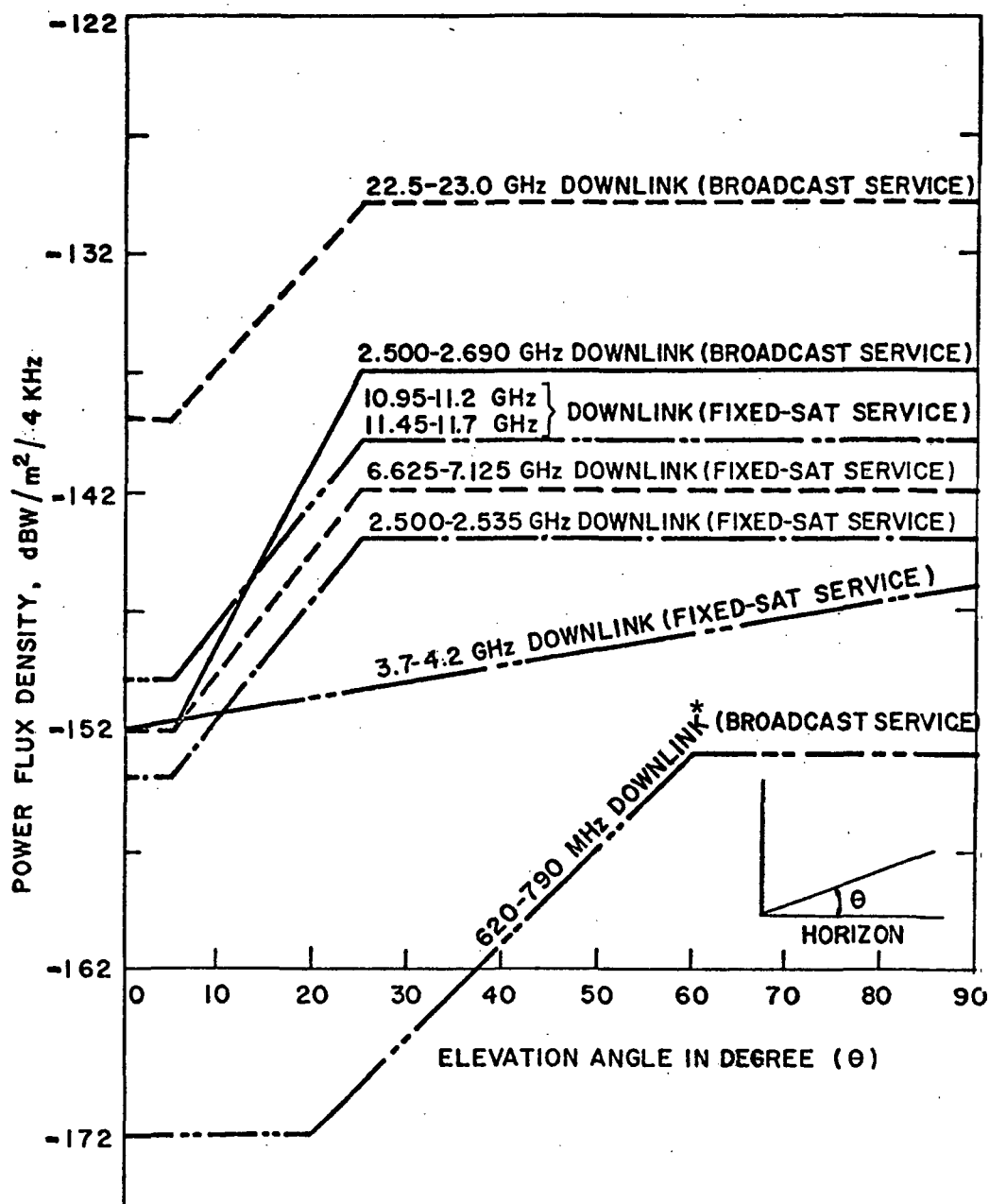
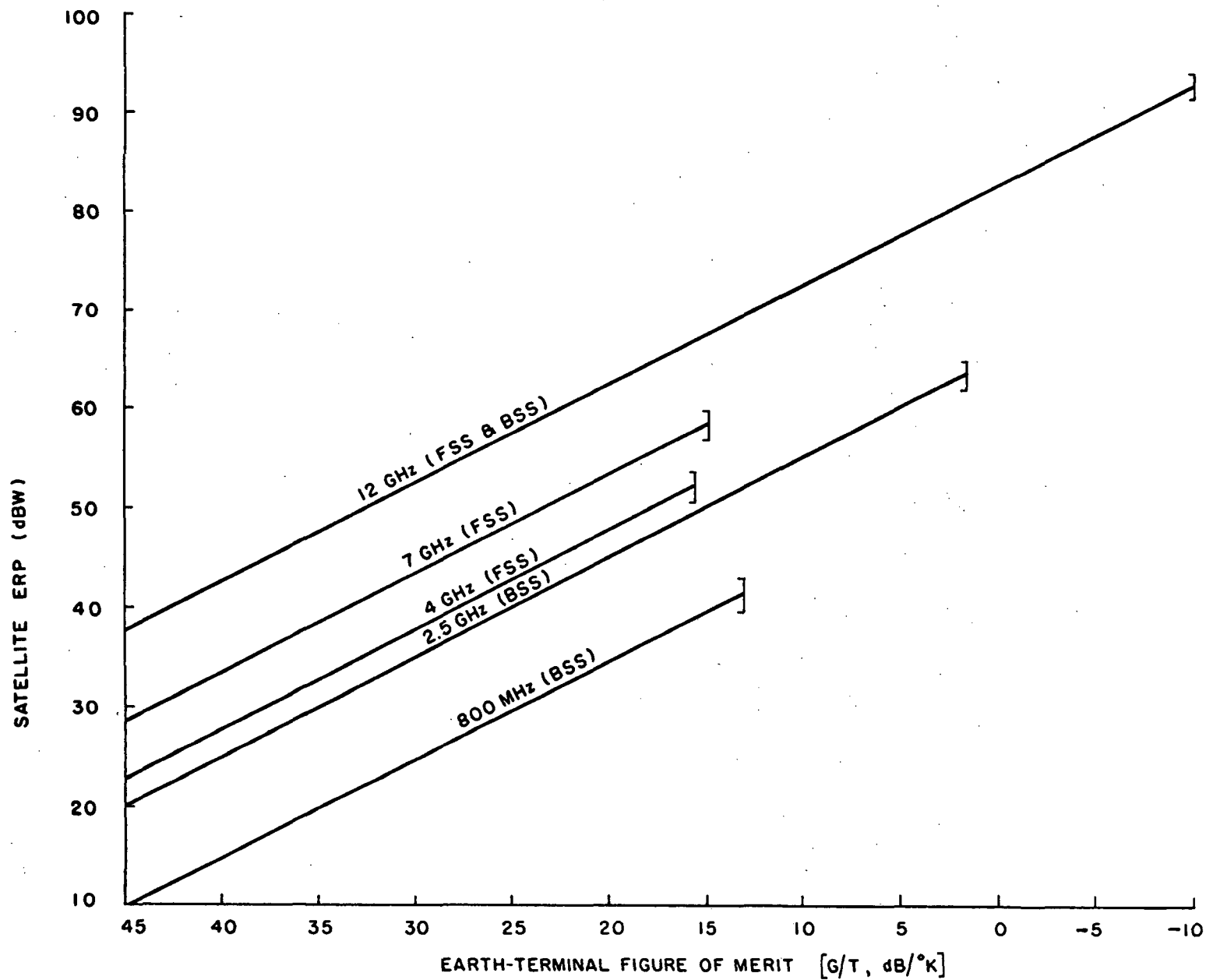


FIGURE 24 MAXIMUM E.I.R.P./ POWER FLUX DENSITY RECOMMENDED BY WARC/CCIR FOR VARIOUS DOWNLINKS

*Limit Not To Be Exceeded Within The Territories of Other Administrations Without The Consent Of Those Administrations.



PERFORMANCES CALCULATED FOR A 99.95 PERCENT LINK RELIABILITY, 52 dB SNR PERFORMANCE, 20 MHz RF BANDWIDTH AND $\frac{B_{RF}}{B_V} = 4.77$

FIGURE 25

and it is established that transionospheric propagation effects (Faraday rotation of the polarization plane, distortions caused by ionospheric dispersion, and Scintillation fading) are appreciable only in the lower end of the allocation table--620-790 MHz and 2500-2690 MHz BSS allocations and 2500-2535 and 2655-2690 MHz FSS allocations. Theoretical analysis shows potential problems for color TV transmissions from space in the 620-790 MHz band--large group delay and its adverse effect on the color subcarrier synchronization, and adverse effects due to the concentration of intermodulation noise in the top part of the demodulated baseband signal (the color subcarrier and the audio signal). The effects on 2.5 GHz band transmission are not expected to be critical. Faraday-rotation could be easily taken care of by using a circular-linear polarization combination and accepting a 3 dB mismatch loss.

Frequency-dependence of atmospheric attenuation is explored and the increased attenuations for higher frequencies are discussed. Also discussed are space diversity and command beam techniques of combating localized, rain-induced deep fades. Based on the attenuation probabilities for various frequencies presented in CCIR USSG Paper IV/1024 (June 26, 1970), the performance of various down links are evaluated in terms of output signal-to-noise ratio for a common set of satellite ERP, earth-terminal sensitivity, and frequency deviation of the carrier by the modulating TV baseband. Figure 26 shows the results of this comparison as a plot of (SNR) output versus percentage time for which that performance is available.

A chapter on man-made environment addresses both indigenous noise and frequency sharing with terrestrial services in the frequency bands of interest. Discussed also are colocation problems, the minimum separation that is required between satellite earth-terminals and terrestrial station in the same band and the various protection measures--site shielding, cross polarization, directional antenna, etc.--which could help to reduce separation distances. Although cross-polarization offers advantages, results of recent ESRO sponsored research shows severe drops in cross polarization isolation in case of snow and wet feed. It is suggested that research be carried out to evaluate the frequency dependence of rain and snow depolarization effects as well as the absolute isolation

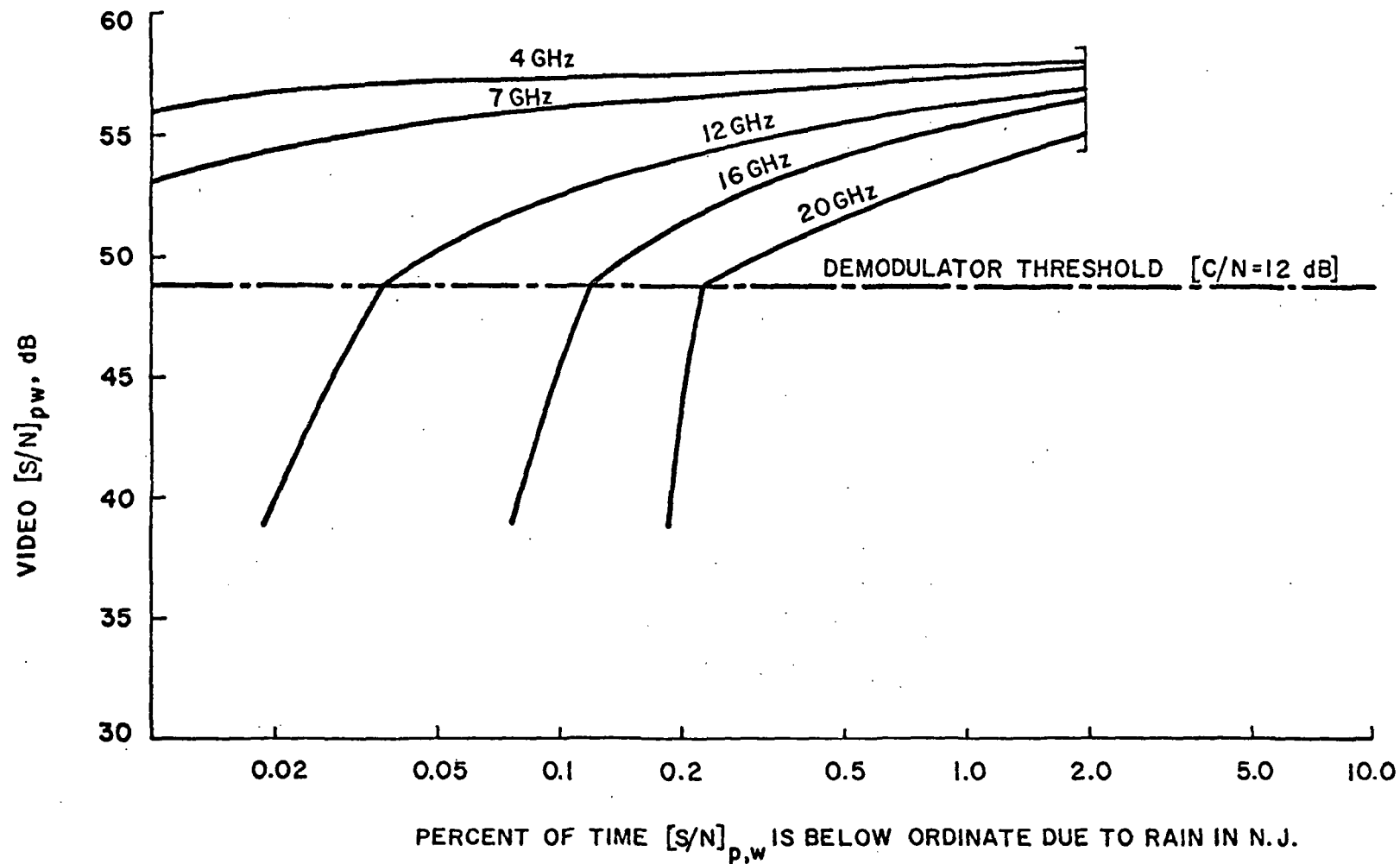


FIGURE 26. COMPARISON OF VIDEO $[S/N]_{pw}$ PROBABILITIES FOR 4GHz, 7GHz, 12GHz, 16GHz, AND 20GHz DOWNLINKS FOR A LINK MARGIN OF 9.5dB ABOVE THRESHOLD AND A B_{RF}/B_V EQUALS 5.95 ($B_{RF} = 25$ MHz).

that is available for a given percentage of time at a given operational frequency.

In the end, the probable networking requirements for educational services and their implication on the choice of transmission frequencies are discussed. Attention is drawn to the problems of accommodating low data rate (up to few kilobits) uplinks from a large, low-cost, earth-terminal complex in the 13 GHz band and it is suggested that such uplinks be accommodated in the 2655-2690 MHz band allocated for FSS uplinks. The limited information carrying capacity of this 35 MHz allocation is pointed out and it is suggested that educational interests attempt to obtain additional frequency space in the neighborhood of S-band for accommodating low-data rate uplinks in case the demand exceeds the capability of the 35 MHz allocation. It is suggested in the memorandum that a possible solution would be to split the 2500-2690 MHz frequency band into two asymmetric parts (7:12 or so) and coordinate the transmissions with FSS allocations through satellite separation and reversing the direction of transmission.

V. OTHER STUDIES

IV. SYSTEMS SYNTHESIS

IV.A. INTRODUCTION

In a previous Progress Report written one year ago^[2], some initial results of efforts to identify a small number of alternative systems of interest for providing educational satellite-based communication services were presented. Since that time, two major events have taken place which have had important implications for our work. First, eight commercial organizations have filed applications with the Federal Communications Commission (FCC) for authorizations to operate domestic satellite services and facilities. The applicants were required to spell out the public service offerings they were prepared to provide for educational purposes. Second, the World Administrative Radio Conference was held in Geneva which resulted in new and important allocations of radio frequencies for space communications services.

Figure 27 shows a revised set of options for educational satellite systems. Options are represented by various combinations of satellite type (dedicated or multipurpose commercial), type of service, downlink and uplink transmission frequencies, modulation, reception by users, and educational mode (whether in-school or outside of schools). Options related to commercial satellite-based educational communication services are discussed in Section IV.B., along with an examination of the adequacy of domestic filings for educational telecommunications. Options related to dedicated educational satellite systems are discussed in Section IV.C.

Figure 28 shows the dedicated educational satellite options that are currently under intensive study. Based on the utilization estimates given in Table 13, we are currently synthesizing a number of alternative systems and studying their sensitivity (in terms of cost, satellite complexity, spectrum space requirements) to earth-terminal type and population, transmission frequencies, and launch vehicles. Studies are also being initiated of organizational and socio-political aspects of the various alternative systems that are being synthesized. A report giving a first-cut analysis of various alternative systems is expected within the next four to five months.

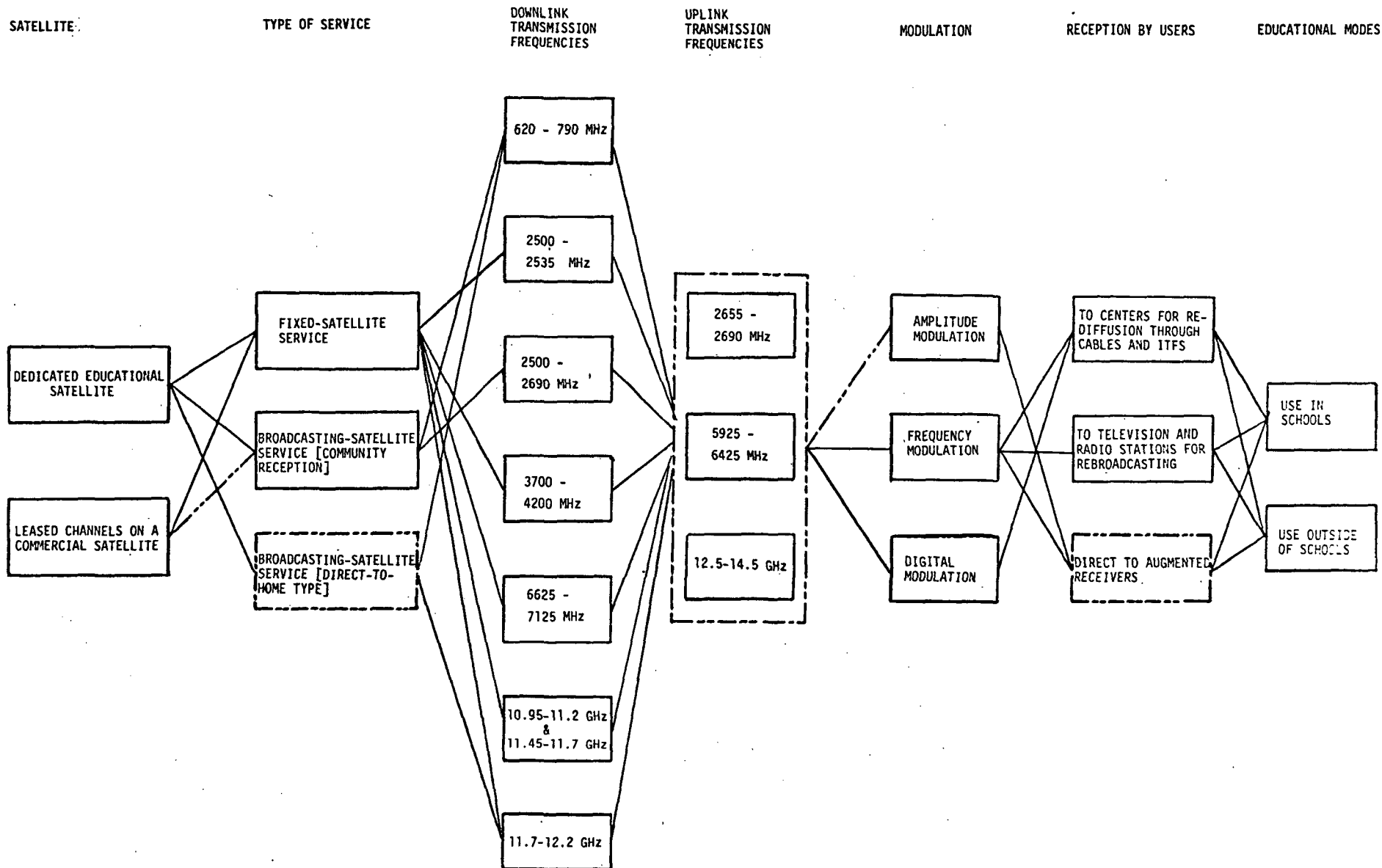


Figure 27. Possible Communication Satellite Systems For Educational Development

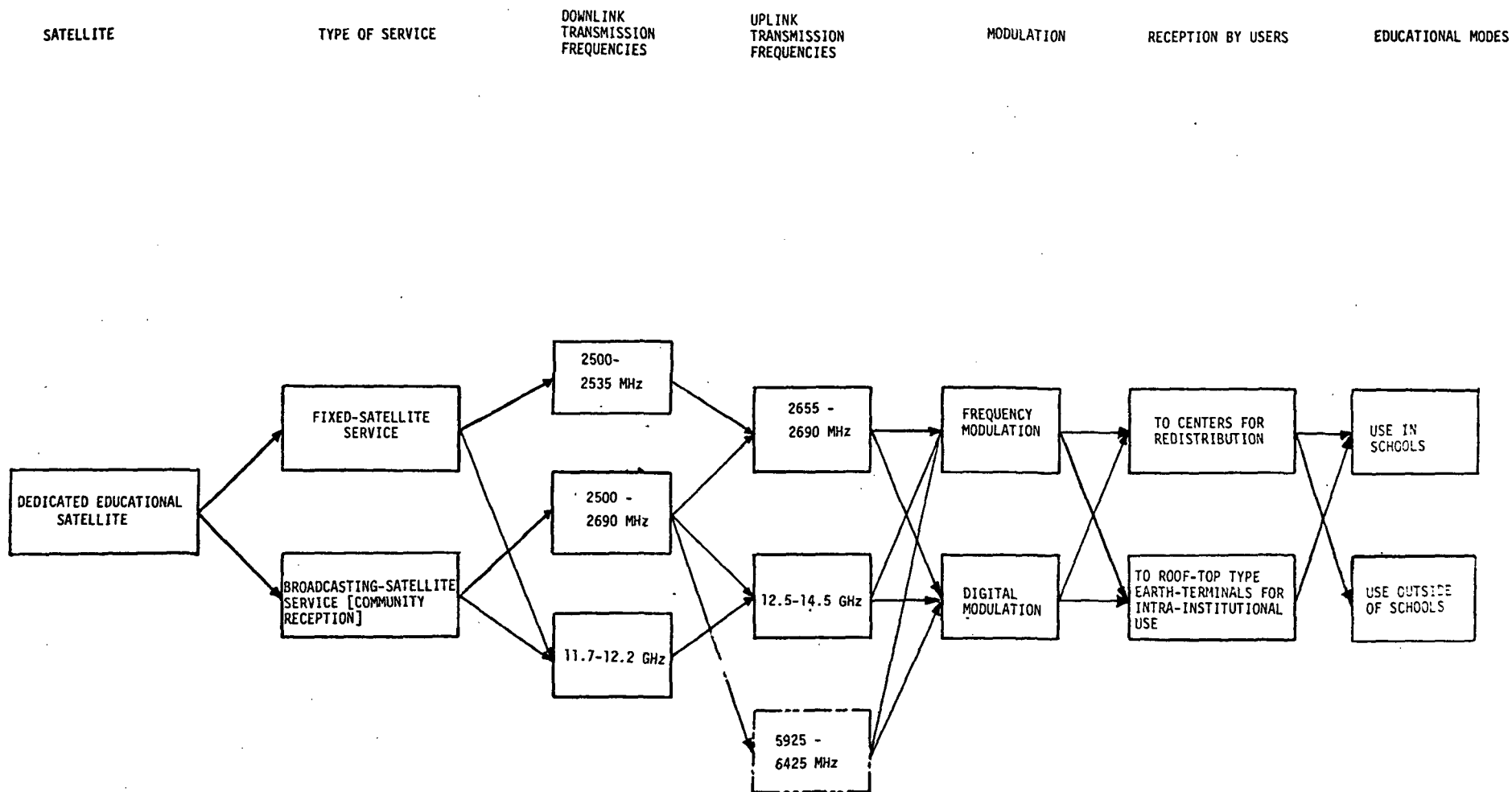


Figure 28. Communication Satellite Systems Under Intensive Study

We have acquired a communications satellite system synthesis computer program developed for NASA by General Dynamics/Convair and, just recently, it has been made operational on the Washington University 360-50 computer. Initial runs are being made to aid in the analysis of various alternative systems. We are currently going ahead with certain modifications in the original program in terms of launch vehicle options and digital transmission techniques. The program is not yet fully debugged and attempts are being made to debug it completely. In this respect we are cooperating with NASA Ames, General Dynamics, and Lockheed Space and Missile Company--organizations that are either using the program or are contemplating its use. However a comment on the General Dynamics/Convair program is in order. Since receiving the program, we have found the technological environment built into it lacking in some of the options which we would like to consider. Therefore, we have decided to use the General Dynamics/Convair program only for the first iterations in the system synthesis.

We have also developed an in-house computer program that maps earth coverage of satellite-borne, narrow-beam antennae for varying satellite locations, inclination of the satellite orbit with respect to the equator, and satellite antennae tilt angle or coordinates of the beam-center on earth. We are currently in the process of extending the computer program to enable us to map earth coverage provided by asymmetrical beam antennae.

Primary emphasis in the synthesis phase so far has been on the technical and economic aspects. In our last Progress Report, work by DuMolin was described which proposed an organizational and administrative framework for a large-scale instructional satellite system. A memorandum on this study, which emphasizes flexible scheduling and a sort of on-demand delivery for overcoming teacher resistance, has been issued.^[19] Future studies will consider another important alternative, namely, a system in which delivery goes around the teachers and schools. In addition, integration of all aspects--technical, economic, and organizational--of various alternatives will be performed (See Figure 20). Guiding factors for the technical system design will include "social engineering" factors to aid in planning and organizing a system which will take into account various resistances. Strategies for bringing the desired educational telecommunications system into being can then be outlined and socio-economic assessment of the impact of such a system carried out.

In Section IV.D., the results of a study by Barnett and Denzau are presented on the future development of instructional television. We have placed this study in the systems synthesis category because it provides useful information concerning costs and alternatives for ground distribution, an important aspect of any delivery system whether satellite or terrestrial.^[20] In the past, most studies concerned with satellite-based educational delivery have often ignored the cost of redistribution after the signal has been received by the roof-top terminal or a cable headend. Barnett and Denzau have compared the costs of institutional interconnection via cable and ITFS for various situations and have presented cost figures as a function of the channel capacity, interconnection distance, and the nature of the headend--whether passive or active.

IV.B. DOMESTIC SATELLITE PROPOSALS AND EDUCATIONAL TELECOMMUNICATIONS

The Federal Communications Commission (FCC), in its Report and Order in Docket 16495 in the matter of Domestic Communication Satellite Systems adopted on March 20, 1970, declared that applicants proposing multipurpose domestic communication satellite systems should discuss the terms and conditions under which satellite services will be made available for data and computer usage in meeting the educational, instructional, and administrative requirements of educational institutions. Of eight applications that were filed (See Table 17), four responded to the FCC directive by spelling out their proposed public service offerings. But only one of the applicants, the MCI Lockheed Satellite Corporation, explored areas other than PTV and ITV and specifically responded to the data communications requirements for administrative data processing, computer-assisted and managed instruction, etc.

One should remember that if total coverage to Alaska is desired, the satellite(s) should be placed west of 115° west meridian (for a minimum elevation angle of 5°), whereas the coverage of the eastern part of the United States with a minimum of 5° of elevation angle requires satellite(s) to be placed east of 137° west meridian. All the domestic proposals contemplate satellite placements within the geostationary arc defined by 94°-125° W. Of a total of 21 satellites proposed to be orbited initially,

Table 17

SUMMARY OF DOMESTIC SATELLITE FILINGS

	AT&T/COMSAT	COMSAT	MCI-LOCKHEED	FAIRCHILD-HILLER
SYSTEM				
No. of Satellites	3 in Orbit 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit 1 ground spare	2 in Orbit 1 ground spare
Orbit Locations [Longitudes]	94°, 104°, 119°W.	99°, 114°, 124°W.	114°, 119°W.	104°, 115°W.
SATELLITE				
Weight at Sync. Orbit	1600 lbs.	1600 lbs.	3900 lbs.	2905 lbs.
Spacecraft Size	110 inches in diameter 230 inches in height	110 inches in diameter 230 inches in height	8' x 5' x 6' [Stowed] x106' [unfurled]	9' in diameter [stowed] 25.3' in length
Stabilization	Spin	Spin	3-Axis [Momentum-wheels]	3-Axis [Momentum-wheels]
Station Keeping	Hydrazine Thrusters	Hydrazine Thrusters	Ion Propulsion Thrusters and Hydrazine Engines	Hydrazine Thrusters
Primary Power	~740 watts [solar cells on drum]	~740 watts [solar cells on drum]	4.4 kW [Solar Cell Array]	750 watts (solar cell cylinder)
Life Time	7 years	7 years	10 years	7 years
Launch Vehicle	Atlas Centaur	Atlas Centaur	Titan III D/Agena	Titan III C
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3700-4.200GHz	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2GHz 12.7-13.25/11.7-12.2GHz	5.925-6.425/3.7-4.2GHz 12.75-13.25/6.625-7.125GHz 2.5-2.69 Trans. Optional Linear
Polarization	Linear	Linear	Linear	Linear
Number of Transponders	24	24	48 [24 for 6/4 GHz operation; 24 for 12 GHz operation]	120 [96 0.1w for narrow-beam point-to-point service; 24 for wide-area TV distr.]
Usable Bandwidth per Transponder	34 MHz	34 MHz	36 MHz	34 MHz
Transponder Output Device	TWT	TWT	TWT	TWTs for Wide-area service; Solid State devices for narrow-beam point-to-point
E.I.R.P. per Transponder	33 dbW [beam-edge]	33 dbW [beam-edge]	34.5 at 4 GHz [beam-edge] 46 dbW at 12 GHz	36 dbW for narrow-beams 35.2 dbW for wide-area coverage at beam-center
EARTH STATIONS				
95-105' cooled T/R[G/T= 41.2 db/°K] 4/6GHz	5	2	--	6
42' cooled R/O[G/T= 35 db/°K] 4/6GHz	--	3	--	--
32' cooled T/R[G/T= 33 db/°K] 4/6GHz & 12GHz	--	--	20	--
32' cooled T/R [G/T= 31.5 db/°K] 4/6GHz	--	3	--	--
32' uncooled T/R[G/T= 29.0db/°K] 4/6GHz	--	25	--	--
32' uncooled R/O[G/T= 29.0db/°K] 4/6GHz	--	99	--	--
25' uncooled R/O	--	--	--	Exact No. N/A
PUBLIC SERVICE OFFERINGS				
Willing to discuss with CPB the terms and con- ditions. Nothing Specific.	Willing to work out some sort of preferen- tial service public broadcasting to meet the genuine requirements of the Corporation for Public Broadcasting[CPB]		Proposes to make avail- able for experimenta- tion in educational ser- vice, the equivalent of five TV channels without charge for a period of five years. Also plans to offer equal trans- mission capacity for the remaining satellite life at a fraction of regular- ly established rates.	[1] Two fully non- interruptable satellite transponder channels, at no-cost, to the Public Broadcasting Service; shared use of narrow-beam channels for "off-shore" locations of Alaska, Hawaii, Puerto Rico and Panama Canal zone; [2] Part-time, free-use, of two satellite transponder channels for health-care delivery throughout U.S.; [3] Free service of one or two instructional tele- vision channels from the satellite directly to a low- cost terminal for school or community use on 2.550-2.690 GHz band; [4] Free use of the space- craft segment for a commu- nication system for Alaska.

Table 17 [Continued]

	HUGHES AIRCRAFT COMPANY	RCA GLOBAL COMMUNICATIONS/ RCA ALASKA COMMUNICATIONS	WESTERN UNION TELEGRAPH COMPANY	WESTERN TELECOMMUNICA- TIONS.
SYSTEM				
No. of Satellites	2 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare
Orbit Locations [Longitudes]	100°, 103°W.	[114°], 121°, 125°W.	95°, 102°, 116°W.	113°, 116°, [119°]W.
SATELLITE				
Weight at Sync. Orbit	452.5 lbs.	638 lbs.	452.5 lbs.	727 lbs.
Spacecraft Size	73 inches in diameter in length	.....	73 inches in diameter in length	72 inches in diameter
Stabilization	Spin	Spin/3-Axis [Not decided]	Spin	Spin
Stationkeeping	Hydrazine Thrusters	Hydrazine Thrusters	Hydrazine Thrusters	Hydrazine Thrusters
Primary Power	220 Watts [Solar cell on the spinning drum]	Aprox. 305 Watts [Solar cells]	220 Watts [Solar cells on the spinning drum]	270 Watts [Solar cells on the spinning drum]
Life Time	7 Years	7 Years	7 Years	7 Years
Launch Vehicle	Thor-Delta M-6T	Thor-Delta 904/ Atlas/TE-364-4	Thor-Delta M-6T	Delta 2914
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12/13 GHz Experiment	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12.75-13.25/11.7-12.2 GHz
Polarization	Linear	Linear	Linear	Linear
Number of Transponders	12	12 for 4/6 GHz operation 12 for 12/13 GHz operation	12	6 for 4/6 GHz operation 6 for 12/13 GHz operation
Type of Transponder	Linear, Frequency Translation	Linear, Frequency Translation	Linear, Frequency Translation	Linear, Frequency Translation
Usable Bandwidth per Transponder	36 MHz	36-37 MHz	36 MHz	36 MHz
E.I.R.P. per Transponder	33.1 dbW for Cont. U.S. 26 dbW for Alaska & Hawaii	35 dbW for cont. U.S. 26 dbW for Hawaii & Puerto Rico	33.1 dbW for Cont. U.S. 24 dbW for Alaska & Hawaii	32 dbW for cont. U.S. [for 4 GHz operation] 38 dbW for cont. U.S. [12 GHz] 26 dbW(4GHz) for Alaska & Hawaii
EARTH STATIONS				
98' cooled T/R* [G/T= 36.7 db] 4/6GHz	2	1	.....	.....
60' cooled T/R [G/T= 36.2 db] 4/6GHz	.....	.....	.....	3
45' uncooled T/R [G/T= 37.5 db] 12/13GHz	.....	.....	.....	1
45' cooled T/R [G/T= 32.3 db] 4/6GHz	.....	.....	7	.....
35'/32' cooled T/R [G/T=31.5db] 4/6GHz	.....	13	.....	.....
35' uncooled R/O** [G/T=27.8db] 4/6GHz	Over 100	.....	.....	.....
20' uncooled R/O [G/T=25 db] 4 GHz	.....	Exact Number not known	.....	Exact Number not known
18' uncooled R/O [G/T=27.1 db] 12GHz	.....	.....	.....	Exact Number not known
15' uncooled R/O [G/T=23 db] 4GHz	.....	.....	.....	.....
PUBLIC SERVICE OFFERINGS				
	Two channels on first satellite with complete backup and no pre-emption. Pre-emptive rights on two channels on spare satellite. Free access to channels from any authorized ground station.	Two TV channels at reduced rates for ETV distribution. Public Radio program distribution on "piggy back" basis on the channels assigned for ETV. Promotional rates for experimental ITV services via standby satellite. Two TV channels for Alaska on regular rate basis.	Willing to offer one or more channels for ETV distribution if the FCC decides that it is in public interest that non- commercial ETV networks should be provided sate- llite channels without charge.	No cost or reduced cost channels for PTV networking.

*Transmit/Receive

**Receive Only

nine fall within the arc 115° - 125° W. and thus are capable of being seen simultaneously from the most eastern part of the United States as well as the most western part of Alaska (Table 17)*. The only proposal that does not contemplate placing a satellite in the arc 115° - 137° W. is from Hughes Aircraft Company and thus it does not fulfill the PBS requirement for the total U.S. coverage, including Alaska, Hawaii and Puerto Rico.

As far as the operational frequency is concerned, all the proposals are confined to uplinks of 5.925-6.425 GHz and 12.75-13.25 GHz and downlinks of 2.550-2.690 GHz, 3.7-4.2 GHz, 6.625-7.125 GHz and 11.7-12.2 GHz. All proposals contemplate using conventional 4/6 GHz operation. Fairchild Hiller is the only one which has proposed a 2.5 GHz downlink with considerably higher E.I.R.P. (55 dBW) for low-cost reception (\$2000 per terminal). It also proposes TV program distribution on 6.625-7.125 GHz. The only proposals that contemplate 12 GHz operation are those of Western Telecommunications and MCI-Lockheed. The E.I.R.P. of 4 GHz downlink beams covering the U.S. mainland (48 states) range between 32-36 dBW whereas those of beams covering Alaska and Hawaii are in the range 26-36 dBW. The Fairchild-Hiller proposal contemplates an EIRP of 34 dBW for the beam covering the mainland and 32 dBW for beams covering Alaska and Hawaii. For 12 GHz operation the EIRP's as proposed are 38 dBW for mainland and 42 for Alaska and Hawaii.

All the proposed systems are capable of satisfying the peak video signal to rms video noise objective of 55 but with earth stations of varying sensitivities. The figures of merit or G/T (Antenna gain to system temperature ratios) have a range 41.2 dB to 25 dB for 4/6, 7/13 and 12/13 GHz operation. Fairchild-Hiller's 2.5 GHz small earth-terminal coverage is designed around 49.8 dB SNR (7 feet diameter antenna), whereas MCI-Lockheed's 12 GHz service is designed to provide 54 dB SNR with an earth station with G/T = 33 dB/°K. The costs of the earth-stations proposed by various applicants seeking authorization vary tremendously--\$6.4 million for each of the five earth stations in the Comsat/AT&T proposals to \$2,000 for 7' terminal for Fairchild-Hiller's 2.5 GHz service.

*All the nine satellites cannot be accommodated in this small arc (115° - 125° W.) even with the most optimistic orbit spacing criteria, in view of the fact that most satellites contemplate using the same frequency bands (4 & 6 GHz, 12 & 13 GHz).

As far as the PBS requirement of multiple point originations is concerned, that is, the requirements that result in transmit/receive type earth stations at multiple locations, all proposals are far from satisfactory. The MCI-Lockheed proposal is the closest, in that it provides some 12 of the 28 locations. Next are RCA and Western Telecommunications that satisfy seven and four locations respectively. The remaining five proposals provide for only two locations. Thus a major modification in the location of the sites for T/R stations would be needed if they were to satisfy the public broadcasting requirements outlined in Section II.

Another thing that has to be kept in mind is that none of the proposals contemplate an orderwire and stereophonic high fidelity (2-15 kHz) channels accompanying the video signal. These would have to be accommodated by multiplexing them with the visual carrier and reducing the visual carrier's deviation. This may result in slightly higher G/T requirements at ground for a given 34 or 36-MHz satellite transponder, transponder power output, and certain performance criteria.

The major problem related to all these proposals is that none, with the sole exception of Fairchild Hiller's 2.5 GHz transponder offer, allows use of low-cost, small earth-terminals and particularly receive/transmit terminals needed for multi-access or intercomputer communication. The reasons that these proposals contemplate using larger earth-terminals are: (1) Relatively low effective radiated power (33-35.5 dBW over 34-36 MHz RF channel); (2) use of conventional 4 and 6 GHz operation where the power flux density reaching earth is limited by a CCIR recommendation to prevent interference to terrestrial common carriers sharing the same band; and (3) The proposed rulemaking that limits the size of the ground transmitting antenna for a 6 GHz earth-to-satellite link to 25-30 foot diameter to increase orbital-spectrum communication efficiency (defined by number of channels/degree of the geostationary arc/MHz). One must not forget the fact that 4 and 6 GHz frequencies are shared with terrestrial microwave facilities and certain coordination procedures are required in earth-terminal siting if interference to and from terrestrial microwave repeaters operating on the same frequencies is to be avoided. This leads to difficulties in colocating the earth-terminal with the ground distribution headend or the interactive terminal cluster as the case may be. Colocation

becomes particularly difficult, often impossible, in urban areas and requires substantial investment in microwave links connecting the far-away earth-terminal with the redistribution facility/terminal cluster.

MCI-Lockheed domestic satellite filing was the only one among eight domestic satellite applications that specifically addressed itself to a broad spectrum of satellite-based educational telecommunications including computer communications. However, operation with 46 dBW 12-GHz transponders of MCI-Lockheed satellite requires earth-terminals with large figures of merit or sensitivities (G/T , dB/°K) even when interactive communication involves relatively small data-rates (few kilobits to few tens of kilobits/second against 40-80 megabits/second involved in digital transmission of NTSC color signal). Figures 29 and 30 show antenna size, noise temperature, and transmitter power trade-offs for a symmetrical interactive communication involving the proposed MCI-Lockheed satellites and 20 kilobit/second data rates. While plotting earth-terminal G/T requirement, a 20 percent activity factor has been assumed, that is, at a given moment a satellite borne transponder is processing only 20 percent of the channels that it is capable of handling. With 4ϕ -CPSK modulation, the satellite transponder with a 36 MHz bandwidth is capable of handling some 1200 20 kb/second channels whereas with 2ϕ -CPSK, the capacity is reduced to some 600 channels. Use of MCI-Lockheed free transponder offerings would thus involve substantial outlays in the ground segment. One could say that for a large population (3,000-18,000) small-earth-terminal environment, even MCI-Lockheed offerings do not lend to an optimal system design. They make sense only when the user population is not large enough to justify a relatively high powered satellite capable of working with low-cost terminals with small G/T s.

Caution is required in evaluating the free offerings made by the domestic satellite system applicants. For example, today MCI-Lockheed Satellite Corporation plans to provide free use of five transponders for five years for educational users. But nobody knows what reduced rates will be charged after the initial five year period expires and during which the channel capacity occupied by educational users might well have gone unused otherwise. Besides, right now they are interested in showing public dividends as they are competing for a non-depleting but limited resource of orbital slots and operational frequencies. The educational

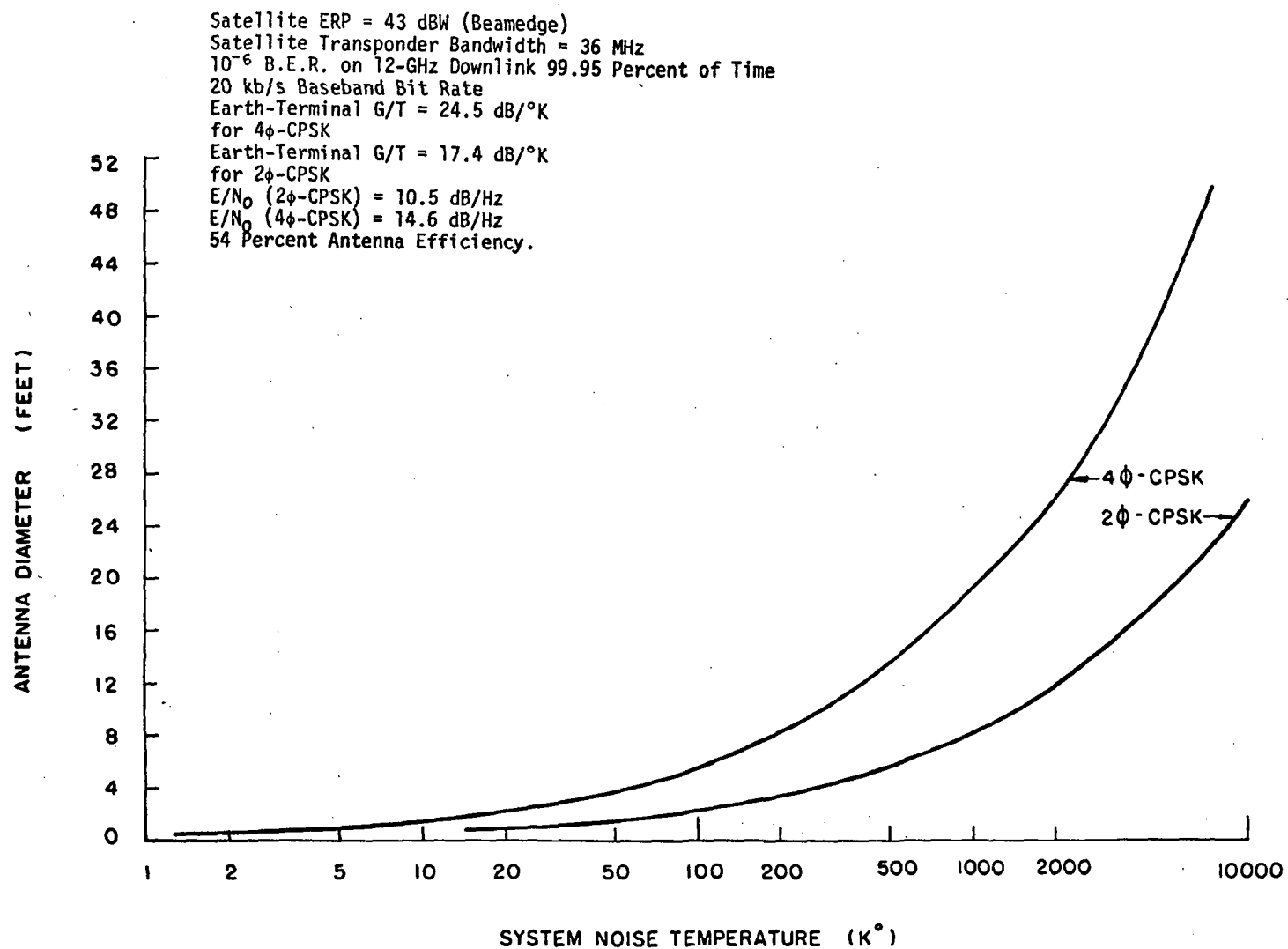


FIGURE 29. TRADEOFF BETWEEN ANTENNA SIZE AND SYSTEM NOISE TEMPERATURE FOR 20 Kb/SEC DATA

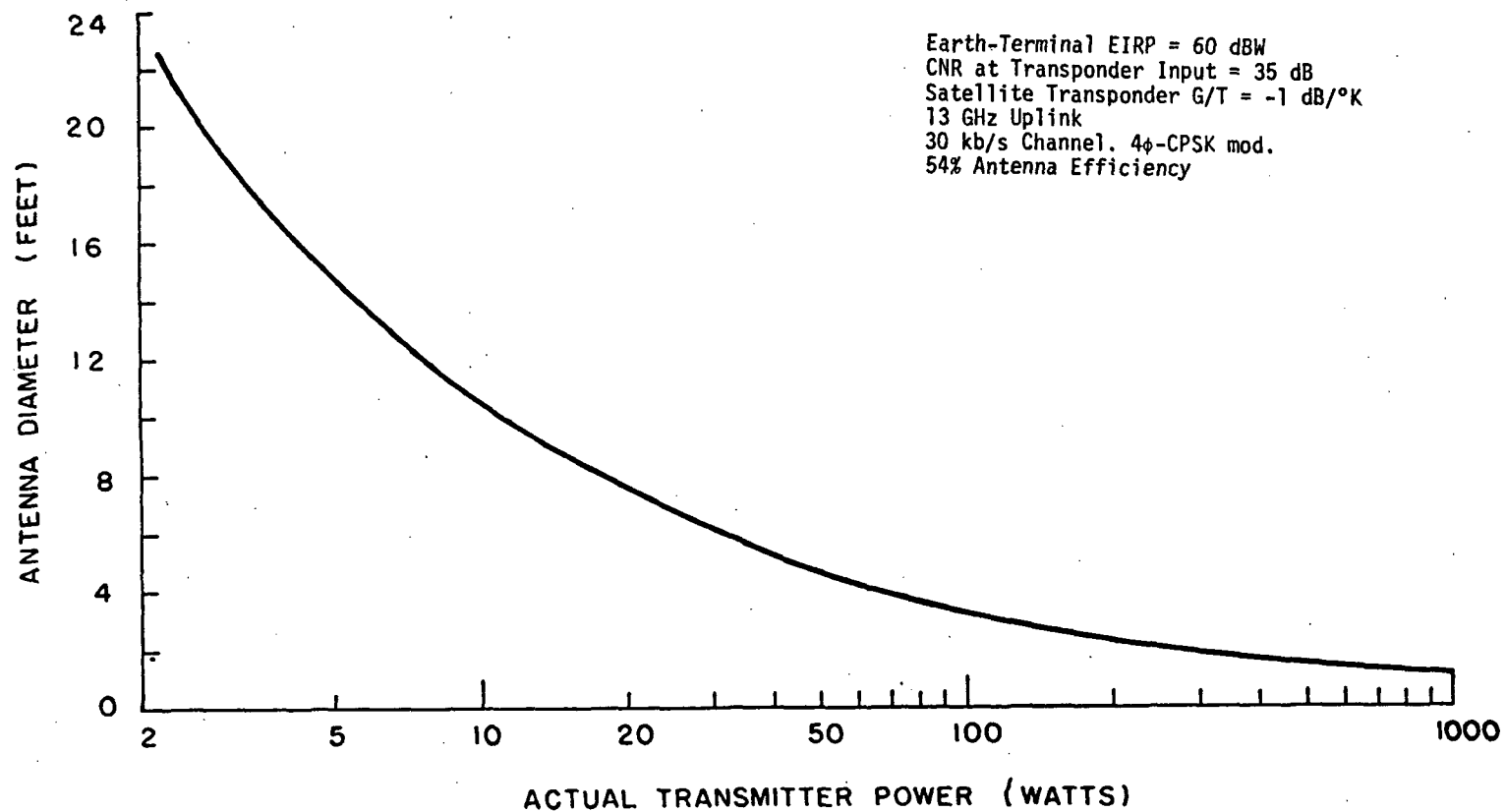


FIGURE 30. ANTENNA DIAMETER AND TRANSMITTER POWER TRADEOFF

community should also be aware of the large investments on the ground that would be needed in order to make use of the limited public service offerings. Also, it should be kept in mind that in all of the proposals, the services are not really "free" or at "reduced rates" in the overall sense. Other users will have to pick up the tab for services supplied to the educational community.

IV.C. DEDICATED EDUCATIONAL SATELLITE SYSTEM

Our continuing exploration of educational applications of communications satellite technology has suggested that satellites may have an important role in

- (1) Interconnecting educational institutions, particularly those related to higher education, among themselves and with certain service centers, for sharing of instructional, research and administrative resources; for providing institutions poor in certain resources with access to services which otherwise might not be available.
- (2) Interconnecting remote and isolated institutions with certain service centers to provide students and teachers therein equitable access to services such as computing, computer-managed/based instruction, etc. that are currently more readily available to their counterparts in urban and suburban areas, and to provide in-service teacher development programs; and
- (3) Delivery of both public as well as instructional television and radio program material to cable and ITFS headends and broadcast stations for either real time or delayed redistribution for in-school as well as in-home utilization.

Figure 31 shows the basic conceptual framework for these services. One should keep in mind that the service requirements include both one-way program delivery (to some extent on-demand basis) as well as interactive services such as computer-interconnection, multi-access remote computing, computer-assisted instruction, teleconferencing, etc. which require two-way receive transmit capability. However, the return links from institutional headends are expected to be low-speed (up to few to few tens of kilobits/

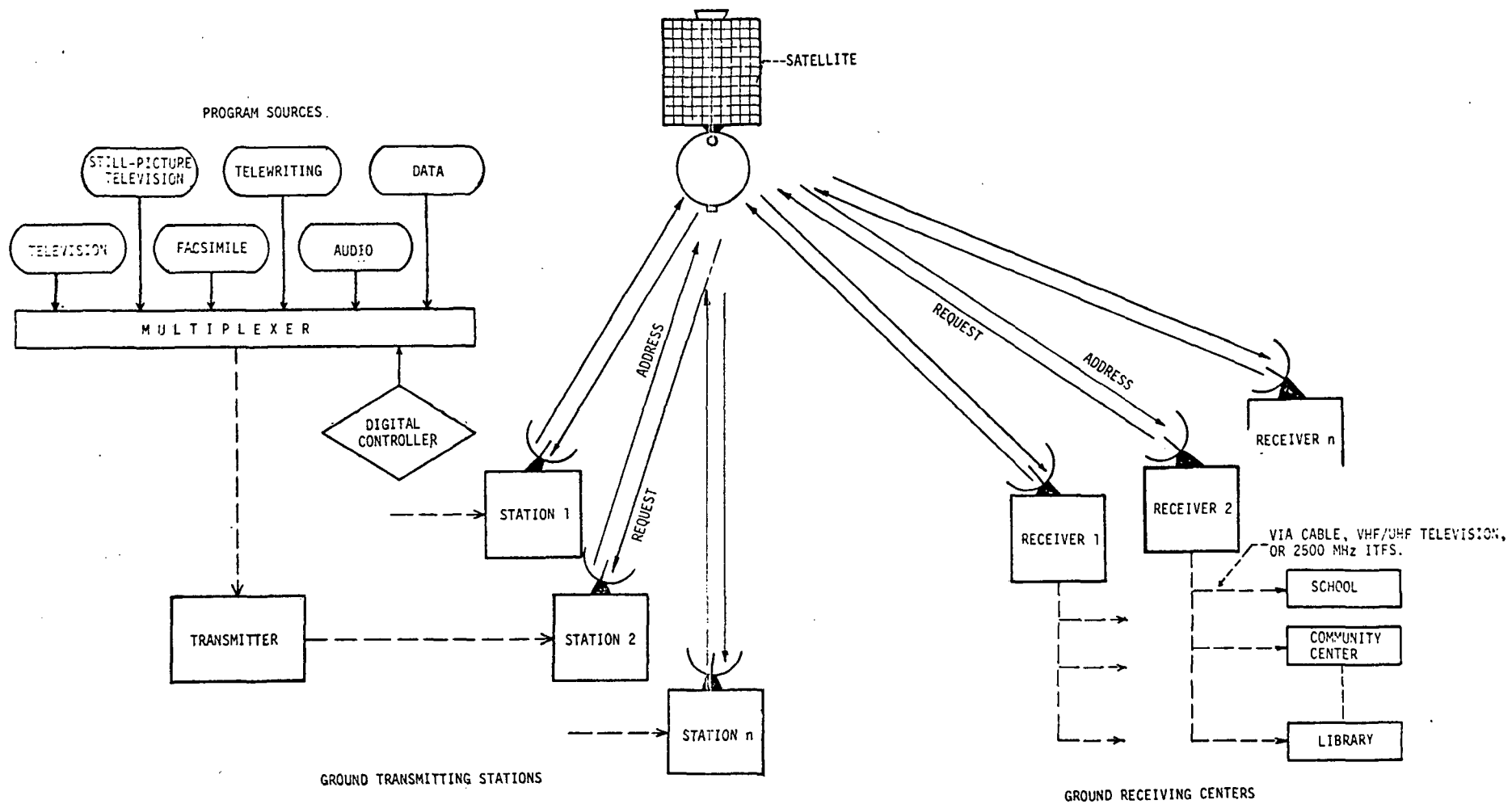


Figure 31. EDUCATIONAL SATELLITE SERVICES

second) whereas the incoming information to them would be several orders of magnitude higher.

One of the major obstacles in the development of the type of interconnections and delivery systems discussed above is the high cost of currently available long-distance telecommunications lines as well as the various inadequacies inherent in a plant that was originally designed for transmission of analog signals only and where economic necessities have restricted each improvement to be compatible with existing facilities. For example, the cost of a telephone line appears to have been constant over the past decade, while the cost of computers has been dropping at about 25 percent every year. If this trend continues, eventually the communication costs will become the dominant cost component of most teleprocessing systems.

According to an SRI study, communication costs are expected to show only a small decrease in the 1970s. This is rather surprising when one considers the advances in terrestrial microwave, coaxial line, millimeter waveguides, and satellite communications that have taken place and have entered into service or are expected to enter into service during 1970s. The fact is that such long-haul systems have indeed dropped the long-haul portion of the telephone line cost and further reductions are expected in its contribution to the overall cost. However, the problem is in the local telephone loop, associated switching equipment and labor costs that account for over 80 percent of the communication costs of long-distance calls. There is very little prospect for any significant cost reductions in this area. This necessitates exploration of communication systems and techniques that bypass the local subscriber plant and associated switching equipment. For communication between fixed points, such as those that are usually involved in most educational situations discussed earlier, low-cost terminals situated in the vicinity of the institutional or community headends offer certain interesting prospects.

However, this is a situation where the multipurpose satellite systems proposed in the domestic filings offer little encouragement due to their use of certain frequency bands that inhibit economic small terminal operation and/or relatively low effective radiated power levels that dictate use of earth-terminals with high sensitivities [G/Ts]. Satellites proposed in the domestic filings are appropriate for an environment of a relatively

small number of high-capacity earth-stations. However, they certainly do not represent the most economic or optimal designs for an environment consisting of a large population of small earth-terminals. The final choice among the options of building an educational satellite system around a few rented channels off a domestic satellite system, or going for a dedicated educational satellite system using relatively higher ERP levels needed for economic large population earth-terminal environment, or, using terrestrial facilities will primarily depend upon whether educational services can be pooled together and upon the size of the user population.

We are currently in the process of synthesizing several alternative educational satellite systems using dedicated satellite(s) to interconnect varying numbers of different categories of earth-terminals located at CATV, CCTV, ITFS, and regional network headends and ETV and ER broadcast stations. We are assuming satellite placement in the geostationary orbital arc 118-132° West to assure simultaneous satellite visibility to the eastern most portion of the continental U.S. as well as the western-most part of Alaska (See Figure 32). Figures 33 and 34 show the coverage patterns under consideration. While drawing these coverage patterns we have taken note of time-zone differences, state boundaries, regional network interconnection and/or affiliation patterns (See Figure 35), and population covered. In past several coverage pattern proposals have been made: (1) A General Electric investigation of network television distribution satellite systems assumes an eight beam coverage that provides for national as well as sub-national coverage possibilities but is primarily designed from the viewpoint of PBS television program distribution; (2) Coverage patterns based on time-zone differences; and (3) Coverage patterns covering equal student populations as proposed by Sheppard in his instructional communication satellite design. The coverage patterns proposed in Figures 33 and 34 present the best compromise, in our opinion, between the instructional and public program delivery requirements and constraints and satellite system complexity. This is an area in which we invite comments from educators and decision makers regarding other alternative coverage patterns that ought to be considered.

Investigation is oriented towards a predominantly small earth-terminal environment with terminal population in the bracket of 3,000-20,000. Launch vehicle options have been limited to Thor-Delta 9(3)04 (6 Castor and 3

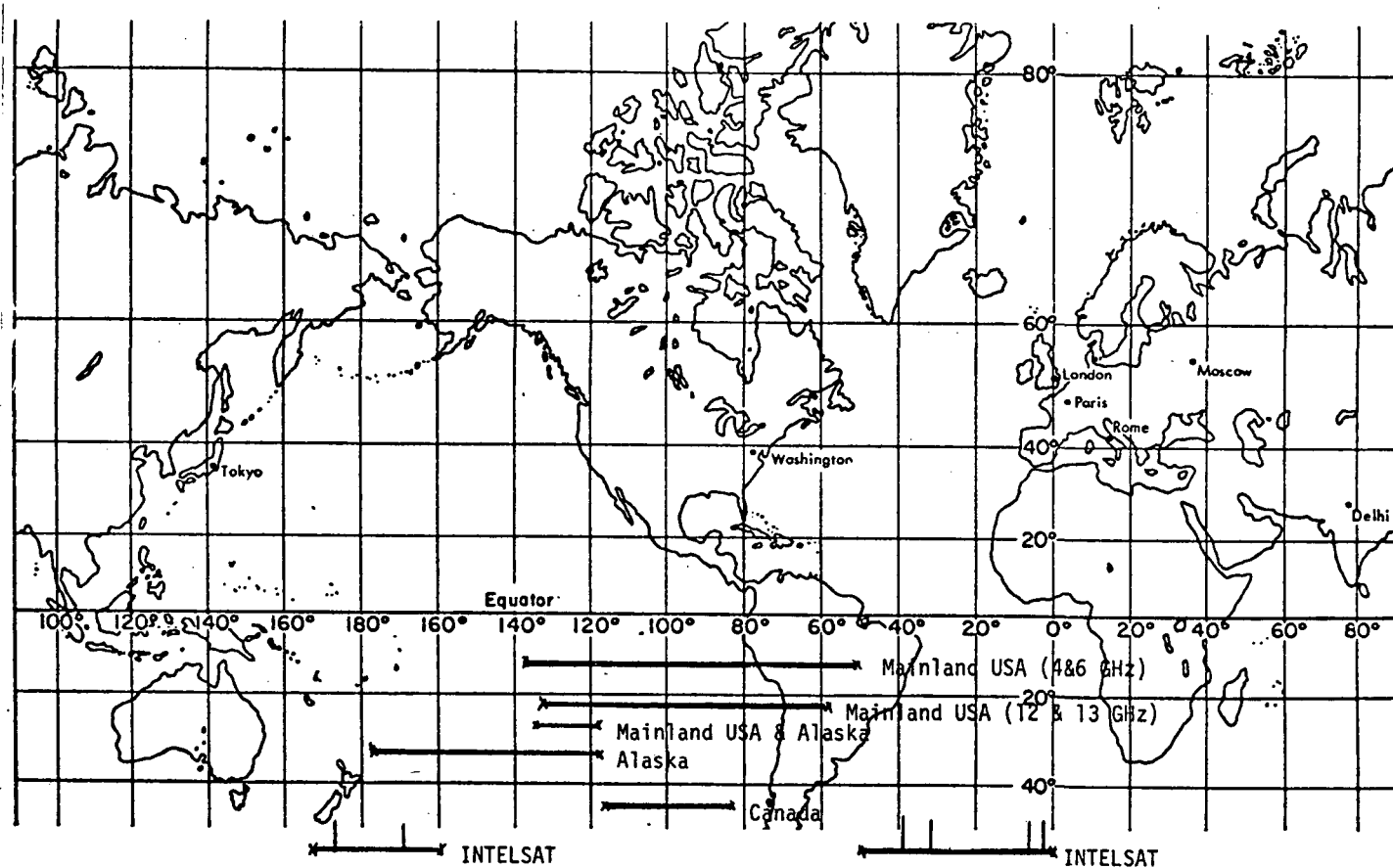


Figure 32. Arcs of Geostationary Orbit Suitable For North American Domestic Satellite Systems

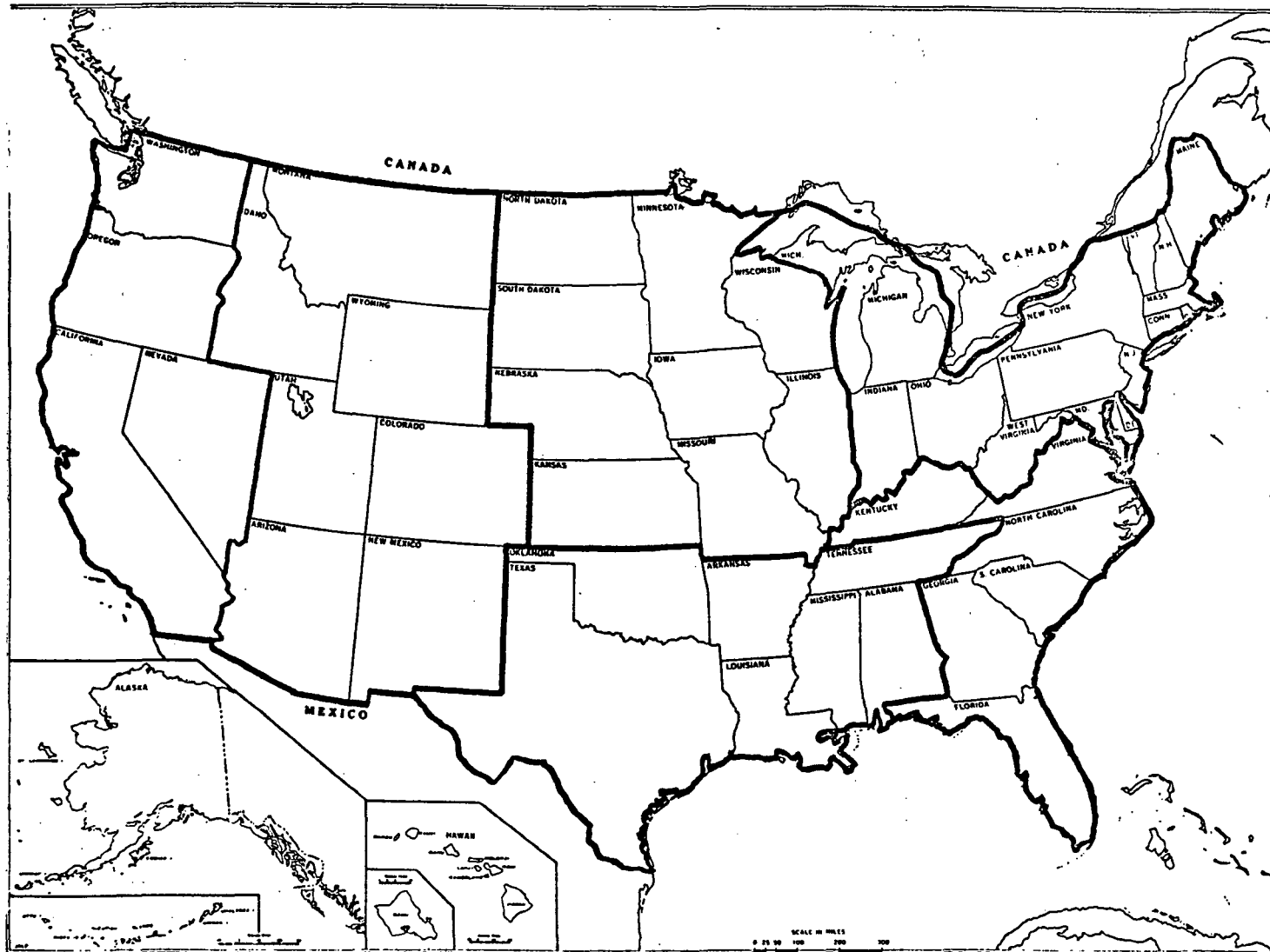


Figure 33. Coverage Pattern Alternative #1

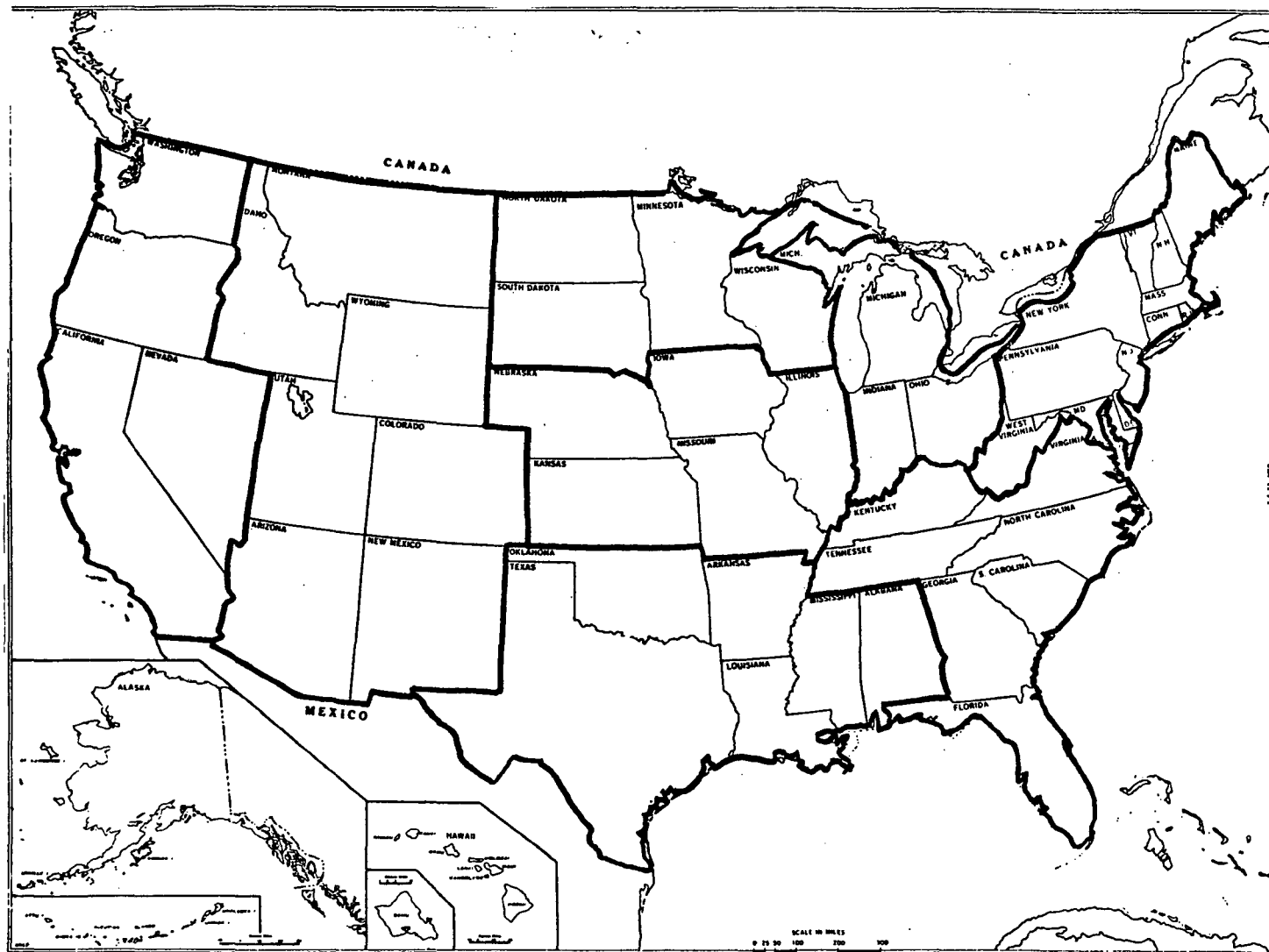


Figure 34. Coverage Pattern Alternative #2

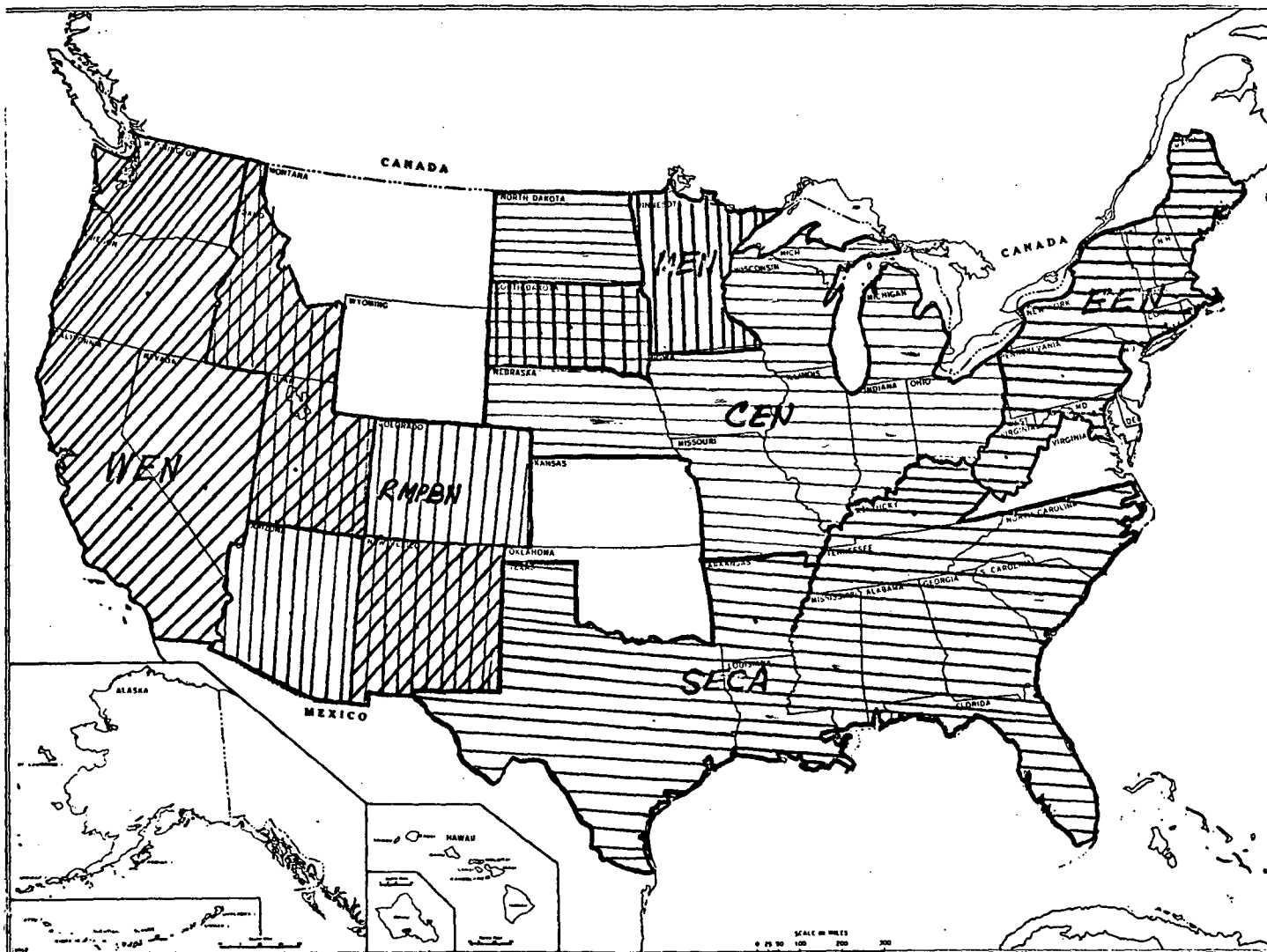


Figure 35. Regional Network Affiliations

Algol/Thor/ID(Transtage)/364-4), SLV-3C/CENTAUR D1-A/B-II, and TITAN IIIC (Uprate). Particular attention is being paid to the use of Thor-Delta in view of its relatively smaller launch and interfacing costs and reliability record. We expect to release a report in the next few months which will contain a first cut at the design of several alternative systems and present sensitivities of the cost of the systems to launch vehicles, service mixes, earth-terminal population, and transmission frequencies. Based on a completed study, the downlink frequency choices have been restricted to 2.5 GHz and 11.7-12.2 GHz frequency bands.

Studies have been initiated towards developing organizational and administrative requirements and constraints for satellite-based delivery and interconnection system(s) which will certainly cut across traditional institutional, state, and school board boundaries. A study by DuMolin^[19] has examined and discussed the organizational and administrative aspects of the system from the viewpoint of overcoming the resistance of teachers upon whom much of the success of system utilization will depend if the status quo in education is to be maintained and continued. Other studies will discuss system requirements from political and managerial viewpoints and lay out an integrated set of organizational constraints and requirements. Forthcoming studies will also construct and discuss conditions or scenarios under which particular systems might become viable. Also being considered are the strategies for pooling educational services and users together to provide the critical mass necessary for the viability of a dedicated satellite system(s), for moving towards an operational system and for financing and administering it.

IV.D. FUTURE DEVELOPMENT OF INSTRUCTIONAL TELEVISION

A study has been performed by Barnett and Denzau of future development of instructional television which concentrates on costs of alternative distribution systems, primarily for ground distribution.^[20] The alternatives are analyzed to proceed in stages as follows:

Stage I

Approximately 1972-1976

Purpose: Experimentation and learning by classroom teachers.

Equipment: Package A. In each school 1 mobile TV set and 1 mobile video tape recorder/player (VTR) per 5 rooms; tape library; other items.

Stage II

Approximately 1975 onward. Depends on successful Stage I.

In substantial degree, full scale use of television instruction in individual schools, averaging 20 percent of classroom time. Continued development of program material and incorporation in formal classroom and individualized instruction.

Equipment Systems: 2 Alternatives

- Package A expanded to provide a TV receiver and VTR in each room, a large school tape library and certain other items.
- Or Package B plus Package C. Package B is a school wire (closed circuit) network to a TV set in each room. Package C is an active school head-end facility equipped with VTR's, tape library, and other items, which sends multiple programs on the school wire network to rooms, on request or according to schedule.

Stage III

Approximately 1976 onward. This stage might occur without Stage II, but its entrance depends on successful Stage I. Full scale use of television instruction, up to 20 percent of class time as in Stage II. But programs are provided by the city school district from a centralized head-end facility to all schools.

Equipment: All alternatives require Package B, the school wire network to a TV set in each room. There are 3 alternatives for feeding programs to the school wire network and TV sets:

- Package D: a 4-channel ITFS broadcast system with centralized school district origination of programs, plus, at each school, an active head-end facility (like Package

C, but of reduced size and activity) to record programs and provide delayed play as needed by schedules.

- Package E; 4-instructional channels on a city CATV system, with centralized school district origination of programs and active school head-ends, as immediately above.
- Package F: a 40-channel school cable system connecting all schools and school district headquarters. The district head-end provide all programs. There are not active school head-ends, since the numerous program repetitions accommodate diverse school schedules without recording and delayed play.

Stage IV

Approximately 1977 onward.. Builds upon previous stages. A substantial degree of satellite relay of instructional broadcasts to the head-ends of city school districts or of schools. These programs supplant some or all of the cities' program origination activity of Stage III or the school origination of Stage II.

Equipment: Package G is a multichannel satellite system which relays to city head-ends. From there the signal travels to schools on a city cable network and to rooms on each school's cable network. Thus Package G substitutes for the city systems of Stage III. Package H is a multi-channel satellite which relays directly to school head-ends. The signals are carried to rooms on each school's cable network. Thus Package G substitutes for the individual school systems of Stage II.

The memorandum includes cost analyses for those packages contained in Stages I, II and III, concentrating primarily upon ground distribution. Satellite system costing remains to be performed in connection with the main thrust of the overall program. The Summary and Conclusions of the Barnett-Denzau study are as follows:

"1. Television instruction could be a magnificent innovation of great importance. It holds large promise in lectures, display and demonstration; in computer assisted instruction; in home as well as school education; and in education of both adults and children. The prospects include increased individualized instruction; repetitions for slow learners, acceleration for fast; and offerings from the best of teachers to all students. Cost savings are also possible.

"2. In this paper, we focus on ITV in schools. This is now in an undeveloped state for two reasons. Technology, both hardware and software, is still immature and has been expensive. And teachers have yet to learn how to use the innovation. The first important stage in the development of ITV is for teachers to experiment with and use TV programs and to learn how to incorporate them in classrooms.

"3. A breakthrough is now at hand for this stage, which will both greatly reduce cost and assist teachers in their learning how to use instructional TV. This is the perfection of inexpensive video tape recorders/players (VTR) and inexpensive tapes and cameras. If schools were provided with these, teachers could view and re-view tapes. They could consider, learn, and experiment with ITV over the next several years, each at his own speed and in his own subject matter. We have conceived a "package A", which consists of 10 mobile VTR's and TV sets, a tape library, and several TV cameras per school of 50 rooms, and proportionate equipment for schools of other sizes. This would cost only about \$5 per student per year, less than 1 percent of the usual school budget. It would seem a small price to pay for successfully introducing and planting ITV in the educational establishment.

"4. We next consider the subsequent use of TV in schools as a major instrument in instruction. We conceive of ITV employed in up to 20 percent of class time in some school districts beginning in about 1974, and conceive that the innovation spreads rapidly to other districts. If an active head-end at each school transmits the ITV programs by cable to the classroom it would cost about \$33 per student per year. If the city school district transmits the programs to the classrooms it would cost only about half as much; this is due to economies of scale in the head-end facilities and labor.

"5. It appears that the most promising system for school ITV in this latter developed stage is a dedicated school-district cable system, which we have termed Package F. This is a 40 channel cable to each school and thence to each classroom. On its multiple channels, the school-district head-end transmits a schedule with numerous repetitions of each program to accommodate diverse individual classes, and also transmits programs in response to special request from teachers. In addition, this system includes a limited number of VTR's, TV booths, cameras, etc. in each school for individual teacher and student use. This aggregate of 40 channel cable services and other facilities costs perhaps \$15 per student per year, about 2 percent of the average school budget. In turn, it provides TV instruction for an average of about 20 percent of class time. The innovation offers considerable opportunity for improving the quality and content of the schools' instructional offerings, or for reducing cost, or both.

"6. The FCC sponsored, 4-channel ITFS service or 4 leased channels on a commercial CATV system appears less desirable. Relative to the 40-channel cable service, above, they provide less flexibility; would be slightly more costly for approximately equal service to classrooms; and in the case of ITFS it is less favorable in signal quality and less attractive for potential expansion of ITV to home instruction."

"7. Satellites distributing national programs have been proposed as a major system in ITV. One concept conceives of service from a national head-end facility via satellites to reception equipment at individual schools; this would be a substitute for active school head-end facilities. Another concept conceives of service to a city school-district cable system from a national head-end facility and satellites to individual city reception equipment; this would be a substitute for active city head-end facilities. In our lack of knowledge of the cost of satellites and satellite reception equipment, we are unable to estimate reliable cost comparisons. We do roughly estimate, however, the national cost of the alternative non-satellite system. This is the cost which the satellite system, if it were of equal capability, would have to equal or improve upon in order to be economically advantageous. We are now engaged in economic research on such satellite systems.

"8. Satellites have also been proposed for areas with small and dispersed populations, such as Alaska. With the advent of inexpensive VTR's and tapes, this attractive innovation is becoming available for such areas. The nature of the costs of a school or classroom VTR system is that they are approximately proportionate to population numbers. Thus, small populations can be served at small costs. In Alaska, for example, the individual classroom or individual school VTR system could provide ITV to its 78,000 school students for a total of about \$3 millions per year, including TV sets. This is alternative to a specialized, many-channel Alaska satellite which would broadcast to school head-end receivers, with distribution on a school wire system to individual TV sets. The \$3 millions is thus a rough estimate of the cost which the Alaska ITV component of a satellite system, if it were of equal capability to the VTR system, would have to equal or improve upon in order to be economically advantageous".

V. OTHER STUDIES

V. OTHER STUDIES

V.A. INTRODUCTION

In this Section, we will report briefly on two studies which are underway which are to some extent in a category by themselves. A study is being initiated with partial support from the Appalachian Regional Commission, under a sub-contract from a grant from the U.S. Office of Education*, to investigate the potential uses of a communications satellite in the Appalachian Region. Design of experiments involving ATS satellites are to be performed as well as identification of potential satellite-based educational and health oriented telecommunications services. Following a brief description of the Appalachian study in Section V.B., an interim report will be presented in Section V.C. of a study, scheduled for completion in June, 1972, of costs and benefits associated with a communications satellite system for India.

V.B. ANALYSIS OF EDUCATIONAL USES OF COMMUNICATIONS SATELLITES FOR THE APPALACHIAN REGION

1. Introduction

As part of our previous work plan, we are in the process of carrying out regional studies of possible educational uses of communications satellites for areas which appear to lack educational telecommunications services and which might lend themselves to satellite utilization. Two regions of interest, namely Alaska and the Rocky Mountain States, appear to be well along in the planning phase. A third region, Appalachia, seemed to be a stage at which we might be of considerable assistance. Accordingly, we proposed to undertake to aid the Appalachian Regional Commission in a study they are performing under a grant from the U.S. Office of Education. The proposal has been accepted. Figure 36 shows the overall study plan and emphasizes the interrelated responsibilities

*Sub-Contract currently under negotiation.

of both Washington University and the Appalachian Regional Commission. The work to be performed is directly related to work to be carried out under our NASA program and therefore, we will not hesitate to use NASA resources where needed. The work being undertaken will now be described.

2. Tasks Being Undertaken

a. An Analysis of Existing Physical Infrastructure for Telecommunications in the Appalachian Region

This analysis will include a description of physical facilities (ETV and ER broadcast stations, school CCTV installations, ITFS systems, educational inter- and intra-state networks, CATV systems, etc.), their location, coverage, and offerings. In addition, the analysis will assess the extent to which such services are being utilized, the nature of such utilization, i.e., commercial functions vs. public service functions, and where the inadequacies lie.

This analysis will require the expenditure of considerable effort for data and information gathering, particularly for material obtainable at the local-government and local-institutional level. The design of the necessary questionnaires to survey and obtain the needed information has been provided by us but data collection and administration will be handled by the Appalachian Regional Commission (ARC) itself because ARC is capable of putting needed pressures to ensure speedy responses to match the study time-schedule requirements. The information which the Appalachian Regional Commission will be responsible for gathering includes field surveys of state ETV networks, community ETV stations, ITFS utilization in schools, school CCTV facilities, and cable TV installations.

b. Identification of the Contribution Which a Fixed Telecommunications Satellite Could Make To Help Meet Existing Educational Needs in the Appalachian Region

In this phase, we will undertake to translate the wishes and needs experienced by the Task Force Study Groups established by the Commission into telecommunications requirements and prepare recommendations for new and/or expanded telecommunications services which may be required to meet

those needs in the areas of vocational education for manpower development, education, health and child development. An analysis will then be provided of ways in which communications satellites might help provide such services. We will provide a summary of the potential role of various kinds of satellites-- domestic multipurpose satellites, NASA experimental satellites and future dedicated educational satellites--in helping to meet regional needs. We will also provide consultation and guidance for the Commission in making cost comparisons between satellite and terrestrial systems and in understanding technical questions concerning satellite operation. Much of the success in this phase and the next phase of the work depends upon how closely the ARC Task Forces are able to state their objectives in measurable terms and the extent to which they are able to specify the nature of services desired (radio, television, computer data, etc.), the sources and destinations of such services as well as the amount of such services desired.

c. Identification of Suitable Experiments for the Appalachian Region To Be Performed Utilizing NASA's Forthcoming ATS-F and ATS-G Satellites

In this phase, we propose to work in close cooperation with the ARC Principal Investigator and Project Director to define at least two experiments, one of which would be compatible with the capabilities of the ATS-F satellite and the other with the ATS-G satellite. These experiments will be consonant with the needs and wishes expressed by the Commission's Task Forces as well as with the objectives of using the technology in question in an experimental demonstration and evaluation of potential ways in which education in the region might be aided. Results of this phase of the study will include technical plans, cost, and necessary organization design. Provided that the other phases of the project which feed into this phase are completed on time, we plan to complete this phase of the work by May 31, 1972. The amount to be sub-contracted to Washington University represents approximately one-fourth of the total Grant to the Appalachian Regional Commission from the U.S. Office of Education. We wish to emphasize that there is an important interrelation between our proposed work and that of the Commission as is indicated in Figure 36. The success of this effort will therefore depend not only upon our own work but also upon the efforts of the Commission, which remains the principal Grantee for the overall study.

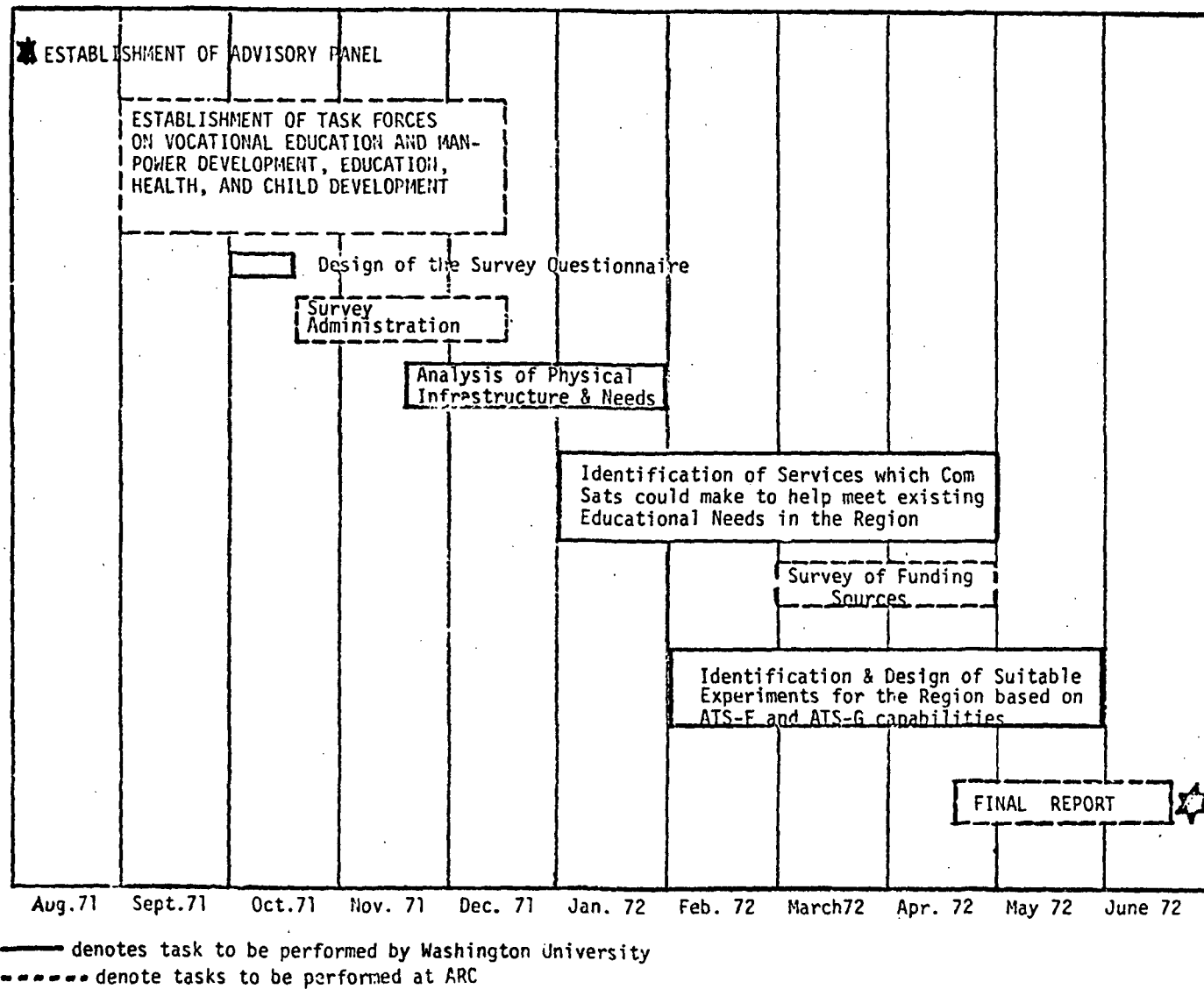


Figure 36. Proposed Time-Schedule for the Appalachian Study

VI. CONFERENCE ON SATELLITES FOR EDUCATION

VI. CONFERENCE ON SATELLITES FOR EDUCATION

In July, 1971, a two-day Conference was held at Washington University on the theme of Satellites for Education. Approximately 90 individuals attended representing all major segments of government, industry, universities and public and private organizations with an important interest in the subject, including NASA, Federal Communications Commission, Office of the President (OTP), U.S. Office of Education, Office of Economic Opportunity, National Education Association, Appalachian Regional Commission, Federation of Rocky Mountain States, Alaska Educational Association, and Public Broadcasting Service. Topics discussed included educational needs and telecommunications requirements, utilization of educational media, educational satellite systems synthesis and strategies for moving towards operational systems. The Conference represented the first major forum for discussion of educational satellites in the United States in which a broad spectrum of concerned parties were in attendance. A highlight was a banquet address by William Danforth, newly elected Chancellor of Washington University. A summary report of the Conference is in preparation. Tables 18 and 19 list the Final Conference Program and List of Participants.

PROGRAM IN TECHNOLOGY AND HUMAN AFFAIRS
WASHINGTON UNIVERSITY, BOX 1106
SAINT LOUIS, MISSOURI 63130

CONFERENCE ON
SATELLITES FOR EDUCATION

JULY 19-20, 1971

CHASE-PARK PLAZA HOTEL
212 North Kingshighway Blvd.
Saint Louis, Missouri 63108.

CONFERENCE PROGRAM

Sunday, July 18, 1971

6:00 - 9:00 PM Registration and Get-Acquainted Gathering

Monday, July 19, 1971

8:45 - 9:00 AM Robert P. Morgan, Conference Chairman - *Opening Remarks*

9:00 - 11:00 AM EDUCATIONAL NEEDS AND TELECOMMUNICATIONS REQUIREMENTS

Moderators: Robert P. Morgan, Washington University
Frank Norwood, Joint Council on Educational
Telecommunications

Robert P. Morgan, Washington University - *An Overview of
Educational Needs and Requirements*

Howard Bray, Appalachian Regional Commission - *Needs and
Opportunities in Appalachia*

William E. Rapp, Federation of Rocky Mountain States -
Needs and Opportunities in Rocky Mountains

Robert R. Bruce, Public Broadcasting Service - *Public
Television Requirements*

Lee C. Frischknecht, National Public Radio - *Public Radio
Requirements*

John C. LeGates, Interuniversity Communications Council -
Needs and Opportunities in Higher Education

11:00 - 11:30 AM COFFEE BREAK

11:30 - 12:45 PM EDUCATIONAL NEEDS AND TELECOMMUNICATIONS REQUIREMENTS:
OPEN DISCUSSION

Resource Persons: Barry D. Anderson, Washington University
Robert Arnold, Alaska Educational Broadcasting Commission
Carter Collins, Office of Economic Opportunity
Robert C. Glazier, St. Louis ETV Commission
Lawrence P. Grayson, U. S. Office of Education
Gordon Law, University of Idaho
Charles Northrip, University of Alaska
William Shamblin, West Virginia University
Jai P. Singh, Washington University

12:45 - 2:00 PM RECESS

Monday, July 19, 1971

2:00 - 4:00 PM

UTILIZATION OF INSTRUCTIONAL AND COMMUNICATIONS
TECHNOLOGY IN EDUCATION

Moderators: Barry D. Anderson, Washington University
Edward Greenberg, Washington University

Edward Greenberg and Barry Anderson, Washington
University - *An Overview*

Fred Cohen, Federal Communications Commission - *ITFS
and CATV for Education*

J. David Lewis, Michigan State University - *Radio and
Television in Instruction*

Bruce Sherwood, University of Illinois - *Computer
Based Instruction; Experience with PLATO Systems*

Daniel Z. Goodwill, Bell-Canada - *An Exploration of
the Future of Educational Technology*

Harold J. Barnett, Washington University - *Sequence
in ITV Development*

4:00 - 4:30 PM

COFFEE BREAK

4:30 - 5:30 PM

UTILIZATION OF INSTRUCTIONAL AND COMMUNICATIONS
TECHNOLOGY IN EDUCATION: OPEN DISCUSSION

Resource Persons: Patrick Bergin, General Dynamics/Convair
Neil Bernstein, Washington University
Bernarr Cooper, State Education Department of New York
Donald S. Culbertson, American Library Association
Arthur Denzau, Washington University
James R. DuMolin, Washington University
James H. Parry, University of Illinois
Michael Sovereign, Naval Post Graduate School
Harold E. Wigren, National Education Association

7:00 PM

BANQUET

Speaker: William H. Danforth, Chancellor, Washington
University

Whittemore House, 6440 Forsyth Boulevard, Clayton, Missouri
(Tickets available at Registration Desk)

Tuesday, July 20, 1971

9:00 - 10:45 AM

SATELLITES FOR EDUCATION: SYSTEMS, EXPERIMENTS AND
POLICY

Moderators: Donald Silverman, NASA Headquarters
Jai P. Singh, Washington University

Jai P. Singh, Washington University - *Options for
Educational Satellite Systems*

A. M. Greg Andrus, NASA Headquarters - *Implications
of Decisions Taken at World Administrative Radio
Conference (WARC)*

Edward R. Graf, Auburn University - *Use of Radio
Frequencies Above 10 GHz for Communication Satellites*

Perry Kuhns, NASA Lewis - *Implications of NASA R & D
In Communications Satellite Technology*

Resource Persons: Melvin Barmat, Fairchild Hiller
John E. Miller, NASA Goddard
Fred J. Rosenbaum, Washington University
Edgar Van Vleck, NASA Ames

10:45 - 11:00 AM

COFFEE BREAK

11:00 - 12:45 PM

SATELLITES FOR EDUCATION: SYSTEMS, EXPERIMENTS AND
POLICY (Continued)

Donald Silverman, NASA Headquarters - *Summary of Past,
Present and Future Educational Experiments Involving
Advanced Technology Satellites*

John Hult, Rand Corporation - *Satellite Systems in
Perspective*

Daniel Wells, Public Broadcasting Service - *A Combined
Educational and TV Network Satellite Distribution System*

Bruce B. Lusignan, Stanford University - *Teleconferencing
and Interactive Communications via Satellites*

Dean Jamison, Stanford University - *Economics of Satellites
for Computer Assisted Instruction for Rural Areas*

Resource Persons: Alex Buchan, MCI-Lockheed Satellite Corporation
Lloyd Krause, Stanford Research Institute
Jeffrey Kurland, Massachusetts Institute of Technology
Delbert Smith, University of Wisconsin
Robert M. Walp, Hughes Aircraft Company

12:45 - 2:00 PM

RECESS

Tuesday, July 20, 1971

2:00 - 3:30 PM

STRATEGIES FOR ARRIVING AT EDUCATIONAL SATELLITE SYSTEMS

(A Panel Discussion focusing on the future development of satellite systems for education. Topics will include: Recent domestic satellite filings and their implications for educational users; Requirements for and implications of a dedicated educational satellite system; The future role of satellites in the educational telecommunications mix; Recommendations for further studies and experiments along with identification of agencies and institutions which could provide support; and Long-range socio-economic implications of educational telecommunications systems.)

Moderators: A. M. Greg Andrus, NASA Headquarters
Lawrence P. Grayson, U.S. Office of Education

Panelists: Robert R. Bruce, Public Broadcasting Service
Richard G. Gould, Federal Communications
Commission
Walter Hinchman, Executive Office of the
President
Richard Marsten, NASA Headquarters
Robert P. Morgan, Washington University
Frank Norwood, Joint Council on Educational
Telecommunications

3:30 - 4:00 PM

COFFEE BREAK

4:00 - 5:00 PM

DISCUSSION OF KEY ISSUES RAISED AT THE CONFERENCE

5:00 PM

ADJOURNMENT

Conference Participants are cordially invited to stay over through Wednesday morning for further informal discussions and campus visits, as well as to work on the preparation of a summary of the Conference and plans for follow-up activities.

CONFERENCE COMMITTEE

Dr. Robert P. Morgan - Chairman
Washington University

Dr. A. M. Greg Andrus
NASA Headquarters

Mr. Robert R. Bruce
Public Broadcasting Service

Dr. Edward Greenberg
Washington University

Mr. Donald Silverman
NASA Headquarters

Dr. Barry D. Anderson
Washington University

Dr. Lawrence P. Grayson
U.S. Office of Education

Mr. Frank Norwood
Joint Council on Educational Telecommunications

Mr. Jai P. Singh
Washington University

CONFERENCE ARRANGEMENTS

Mr. James R. DuMolin
Mrs. Emily Pearce
Miss Barbara Morose

WASHINGTON UNIVERSITY PROGRAM ON APPLICATION OF COMMUNICATIONS SATELLITES TO EDUCATIONAL DEVELOPMENT

PROJECT MEMBERS

Barry D. Anderson
Graduate Institute of Education

Neil N. Bernstein
School of Law

Banarsi D. Dhawan
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Edward Greenberg
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Barbara Morose
Center for Development Technology

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Emily Pearce
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Roger McClung
Department of Economics

Nancy H. Morgan
Department of Appl. Math and Computer Sci.

Burton Newman
Department of Electrical Engineering

Fred J. Rosenbaum
Department of Electrical Engineering

Robert M. Walker
Department of Physics

TABLE 19

WASHINGTON UNIVERSITY CONFERENCE ON SATELLITES FOR EDUCATION

Chase-Park Plaza Hotel
Saint Louis, Missouri
July 19-20, 1971

LIST OF ATTENDEES

1. Barry D. Anderson
Assistant Professor of Education
Box 1183, Washington University
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2. James W. Armsey
The Ford Foundation
230 East 43rd Street
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3. A. M. Greg Andrus
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15. Bernarr Cooper
Chief, Bureau of Mass Communications
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16. Kenneth Crandall
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%MCI-Lockheed Satellite Corporation
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Associate Professor of Architecture
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24. Albert J. Fleig
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Communications & Navigation Division
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25. Lee C. Frischknecht
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44. Perry Kuhns
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58. Robert P. Morgan
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VII. EDUCATIONAL ASPECTS; PROFESSIONAL ACTIVITIES

VII. EDUCATIONAL ASPECTS; PROFESSIONAL ACTIVITIES

The period in question saw the completion of three master's theses (Sharma, Sene, Ohlman). Currently seven graduate students are being supported from program funds. Two of these, (Dhawan, Jackoway), are pursuing Ph.D. programs. A significant development during the period in question has been the creation of a new master's degree program in Technology and Human Affairs (See Figure 37). Sponsored jointly by the Schools of Engineering and of Arts and Sciences, this program offers both M.S. and M.A. degrees, depending upon student background and interests. The program should permit more direct involvement of students with problem-oriented thesis studies such as those in the Satellite-Education project and a higher output of degree candidates. The financial support provided by the NASA program has, in a very real way, made the creation of the new Technology and Human Affairs Program possible.

During the spring of 1971, an interdisciplinary seminar course on Satellites, Media and Education was offered and achieved a somewhat reduced enrollment from the previous year. In the spring of 1972, the course will be broadened and incorporated formally in the Technology and Human Affairs Program as THA 551, Technology, Communications and Education. In addition, weekly seminar meetings directly related to the Satellite-Education program have been held on a year round basis and are currently averaging about 20 persons per week. These seminar meetings have helped to attract new faculty participants who are capable of contributing to the research effort.

The educational aspects of the program were described in detail in an article published in a Special Engineering Education issue of the Proceedings of the IEEE^[21] and in a paper presented at the Annual ASEE Meeting in Annapolis.^[22]

Visitors to the Washington University campus during the previous year included participants in the Conference on Satellites for Education (See Table 19). Approximately ten of these participants, including A. M. Greg Andrus, D. Silverman, J. Miller and A. Fleig of NASA stayed an additional day for intensive discussions. Seminar speakers during the year included Dr. Dean Jamison of Stanford University and Dr. Kenneth Polcyn of the Academy for Educational Development.

Figure 37

TECHNOLOGY AND HUMAN AFFAIRS

AT

WASHINGTON UNIVERSITY

Washington University is establishing an interschool, interdepartmental masters degree program in Technology and Human Affairs in September, 1971. The purpose of the program is to enable students in engineering and the social, physical and biological sciences, who place a very high priority on social relevance, to focus their technical skills and interests on problems of housing, education, transportation, communications, environmental quality and urban, rural and international development. The program offers opportunity for study in fields related to the application of science and technology to pressing national and international problems, as well as to assessing the social and environmental implications of past, present and future technology. Students address real problems through involvement in project work or policy studies and contact with public and private agencies. A small, central core of courses provides a mutual meeting ground for students in a variety of disciplines while, at the same time, individual interests and needs are met through a flexible system of independent study and fieldwork. The program includes study in the areas of technology assessment and public policy.

The Technology and Human Affairs (THA) Program has several purposes:

1. To introduce scientists and engineers to the social, political and economic aspects of science and technology and to acquaint students of the social sciences and humanities with the uses and effects of technology and the physical sciences.
2. To provide interdisciplinary teaching and research experience for interested faculty, and interdisciplinary educational and research experience for graduate students.
3. To provide professional training appropriate for a variety of administrative and technical positions.
4. To address problems which are emerging from the interactions of technology and society and to progress toward problem solutions.

Both M.S. and M.A. degree programs are available, depending upon the background and interests of individual students. The degree requirements call for completion of 24 hours of courses and seminar work with satisfactory grades and an acceptable master's thesis approved by an interdisciplinary faculty advisory committee. At least one course each semester must be selected from among those offered specifically within the Technology and Human Affairs Program. The courses likely to be offered in 1971-1974 are the following:

- THA 500. Independent Work.
- THA 512. Technology Assessment and Public Policy.
- THA 521. Technology and International Development.
- THA 531. Technology, Resources and Environment.
- THA 551. Technology, Communications and Education.
- THA 591. Special Topics. (Technology and Urban Problems.)

Additional courses and seminars taken by a student may be selected to meet his own needs and interests. A wide variety of courses relevant to the Technology and Human Affairs Program are offered in various departments of the University.

A major consideration which led Washington University to initiate the THA Program was the interests and availability of an outstanding group of faculty members from key disciplines, many of whom have already worked together on socially relevant research and education. A single faculty advisory committee consisting of members appointed from the faculties of the School of Engineering and Applied Science and the Graduate School of Arts and Sciences has been established as the responsible academic body for the THA Program. Advisory Committee members include the following Washington University Professors:

<u>NAME</u>	<u>DISCIPLINE</u>	<u>RELEVANT THA INTERESTS</u>
Barry D. Anderson	Education	Impact of Technology on Education.
Harold J. Barnett	Economics	Natural Resource Economics, Economics of Communications; Government and Business.
Robert Boguslaw	Sociology	Sociology of Science and Technology; Social Systems Analysis and Design.
James W. Davis	Political Sci.	Governmental Organization and Administration; Social Welfare Policy.
Anthony T. DiBenedetto	Chem. Eng.	Application of Materials Technology.
John P. R. Falconer	Architecture	Housing, Building and Physical Planning; Urbanization and Rural Development.
David Hatcher	Civil Eng.	Building Technology; Urban Engineering.
Daniel H. Kohl	Biology	Analysis of Complex Ecological Systems.
Robert P. Morgan (Program Chairman)	Chem. Eng.	Application of Communications Satellites to Educational Development; Energy and the Environment.
Seymour V. Pollack	Computer Sci.	Social Implications of Computers; Automobile Safety; Analysis of Environmental Data.
Fred J. Rosenbaum	Elec. Eng.	Communications Technology for Urban and Rural Development.
Robert M. Walker	Physics	Science, Technology and International Development.

Students will have a number of on-going project and fieldwork areas to choose from in such areas as Technology, Communications and Education; Building Materials, Components and Processes for Urban and Rural Development; Automobile Safety; The Nitrogen Cycle in a Complex Ecological System; Energy Assessment and Policy Studies; Social Implications of Computers; Science, Technology and International Development; Conversion of Military-Oriented R & D to Civilian Uses; Recycling of Materials; Intermediate Technology and Industrialization.

Successful development of the THA Program will have a major impact on the School of Engineering and Applied Science and upon the nature of engineering education at Washington University. The THA Program represents an important mechanism by which the School is attempting to redirect its expertise and resources in socially relevant directions. The Program will add an important new dimension of technological literacy to liberal education in the 1970's for students in Arts and Sciences. Through the interdisciplinary efforts of THA students and faculty, working in one or more challenging areas, new ways will be found to utilize the University's resources in helping to meet societal needs. Finally, graduates of the program will have received an education which will enable them to respond more effectively to the challenges facing our society.

For further information, contact Robert P. Morgan, Chairman, Program in Technology and Human Affairs, Box 1106, Washington University, St. Louis, Missouri 63130.

Washington University program participants made frequent trips to Washington, D. C. for purposes of consultation with NASA officials and representatives of the Office of Education, Public Broadcasting Service, Federal Communications Commission, National Education Association and Joint Council on Educational Telecommunications. Other places visited included the Computer-Based Educational Research Laboratory at the University of Illinois.

During the year, individual program participants have been involved in professional activities related to the program. R. P. Morgan, Program Coordinator, presented a paper summarizing the Washington University Satellite-Education program at an International Conference on Educational Satellites at Nice, France.^[23] He was a contributor to and on the Editorial Committee for Volume 26 of Progress in Astronautics and Aeronautics, "Communication Satellites for the 70's, Systems" published by the MIT Press. Professor Morgan is Chairman of two sessions on "Satellite Systems in the Public Interest" to be held at a forthcoming National Telecommunications Conference in 1972. He was elected to the Board of Directors of the International Division of the American Society for Engineering Education and appointed to the Executive Committee of Washington University's School of Engineering and Applied Science.

Jai P. Singh, Research Engineer, was appointed to the Communications and Broadcast Satellite Systems and Spectrum and Orbit Utilization Subcommittees of the Satellite Systems Committee of the IEEE Aerospace and Electronics Group. He is presenting a paper on the Satellite-Education Project at the Conference on "Space for Mankind's Benefit" in November at the HATS Space Congress, Huntsville, Alabama. He attended, along with A. Denzau, a planning conference on satellite utilization held by the Appalachian Regional Commission.

Professor Fred J. Rosenbaum, in addition to participating in several professional meetings, assumed the duties of Editor of G-MTT Transactions of IEEE. Professor Robert M. Walker, a member of the Satellite-Education Task Force, received the NASA Medal for outstanding scientific achievement. Professor Barry D. Anderson was awarded a grant from the U.S. Office of Education to develop a causal model relating bureaucracy to alienation to achievement of students in schools.

VIII. FUTURE WORK AND PROGRAM EVALUATION

VIII. FUTURE WORK AND PROGRAM EVALUATION

VIII.A. FUTURE WORK

We are currently in the process of defining our tasks and requirements for future work. The program is now funded through August, 1972. At that time approximately four-fifths of the Needs Analysis and two-thirds of the Systems Synthesis work as defined previously (See Figure 1) should be completed. There will be need for continuing effort, particularly in the areas of organizational, administrative and program production aspects of educational satellite systems, socio-economic assessment of synthesized alternatives and strategies for arriving at operational systems. Furthermore, there is considerable interest in pushing forward with definition of and involvement in educational experiments involving communications technology.

We anticipate that a fourth year of support will enable us to achieve with some degree of satisfaction the primary goals and objectives of our program in the needs analysis and systems synthesis areas and serve as a transition to more direct involvement with user groups in both policy-planning studies and actual educational experiments involving communications technology. Specific research tasks are in the process of being defined which plug gaps which have become apparent during the previous year and which capitalize upon the interests and expertise of interdisciplinary faculty and staff members. In particular, Dr. Nicholas J. Demerath, Professor of Sociology, will contribute much needed expertise in the area of organization and management of enterprises, and diffusion of innovation. Other new faculty members who are expected to contribute to the project include Bryce Hudgins, Professor of Education, whose fields of expertise include educational psychology and the instructional process.

In the area of communications technology studies, work has been initiated towards design and exploratory R and D of a multichannel 12 GHz receiver for use with cable television headends. This work, which gives significant promise of providing a major advance in the development of satellite systems technology, is now at the stage where a significant new funding input is required.

In the area of Needs Analysis, a first iteration has been completed of estimated ranges of utilization of educational technology in education and that portion of the utilization for which satellite-based delivery is likely. More work has to be performed to refine these estimates, to extend them to in-home and vocational education, to determine the conditions which are likely to lead to the desired utilization and to assess the impact of such utilization on education. As part of this analysis, studies are underway of costs and benefits of existing educational technology systems, and of ways of improving the effectiveness and productivity of technological innovation in education.

In the area of Systems Synthesis, a detailed synthesis is being developed of a high-powered, dedicated educational satellite system capable of receiving signals from and transmitting signals to schools and redistribution points. Work will continue to perfect the systems design and to look at detailed aspects of costing and ground distribution. In particular, regional distribution to Appalachia and possibly other regions will be examined. Emphasis will be placed upon organizational and administrative questions, upon program production aspects, upon in-school versus in-home delivery, upon socio-economic impact studies and upon strategies for moving towards operational systems.

VIII.B. PROGRAM EVALUATION

Some 26 months have elapsed since our program was initiated. The first year could be characterized as one in which we were learning what to do and how to do it within the context of the broad objectives of the program as originally stated, namely:

1. to assess the role of communication satellites as a means of improving education in the United States as well as in less-developed areas of the world;
2. to generate basic knowledge which will aid in making rational decisions about satellite application in the field of education in the years ahead;
3. to devise systems and strategies for improving education utilizing communication satellites, and to carry out experiments

which may be required to evaluate the effectiveness of such systems; and

4. to educate individuals who will be knowledgeable about aspects of satellite communications policy which transcend any single discipline and which relate to an important social area of application, namely education.

Since then, the basic idea which has motivated this program, namely that there are potentially beneficial applications of communications satellites to help meet educational needs which are worthy of careful study, has continued to bear up well. Although no final, definitive conclusions have been reached, this idea is even more promising than it had appeared originally and seems to be much further along towards implementation and more visible, perhaps in part because of our efforts (See Section VI and VII). Our program continues to be relevant to the needs and objectives of both NASA and the United States by focusing upon devising ways to utilize space science and technology to aid in helping to meet human and societal needs.

A major change took place in our program between year 1 and 2. In the second year, the program became much more responsive to the needs of operational agencies at NASA. Tasks were more tightly defined and the broad initial objectives of the program considerably narrowed. Major progress was made in the Needs Analysis, Communications Technology Studies and System Synthesis areas. On the other hand, certain activities of great interest to our interdisciplinary group, for example, the design and implementation of an educational media center had to be curtailed, in part, because of lack of external interest and support.

In conclusion, the period of this Progress Report has seen a substantial increase in the research output of the overall program (See Section IX). We have succeeded in creating an interdisciplinary research and education base with capability for tackling a broad range of problems dealing with social applications of communications technology. We are now in a strong position not only to continue to contribute to the research program of NASA but also to assist potential user agencies in the future.

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